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ABSTRACT

This guide is designed to assist industrial vocational instructors in teaching a course on fluid power and basic hydraulics. Covered in the unit on the basics of fluid power and hydraulics are the following topics: the fundamentals of fluid power and hydraulics, basic hydraulic circuits, and servicing a hydraulic jack. The second unit, consisting of 18 lessons on the components of hydraulic systems, deals with the following topics: reservoirs; cleaning and inspecting vented reservoirs; laces, fittings, and couplers; replacing a reusable hose end; seals; installing an O-ring; installing a mechanical seal; filters; hydraulic fluids; pumps; pump operation; disassembling, inspecting, and reassembling a gear pump; disassembling, cleaning, inspecting, and reassembling a pressure-compensated variable displacement pump; hydraulic valves; disassembling, inspecting, and reassembling a directional control valve; cylinders; hydraulic motors; and hydraulic accessories. Each unit contains both informational and demonstration lessons. Included in the information lessons are a title page, an outline of key points, transparency masters, review points, an assignment sheet, and evaluation items. The demonstration lessons consist of a title page, steps of the procedure being taught, review points, and evaluation items. A competency profile concludes the guide. (MN)

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Instructor's Guide

FLUID POWER/BASIC HYDRAULICS

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Produced by the Instructional Materials Laboratory
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FOREWORD

The industrial vocational instructors of today face the challenge of helping students acquire skills and knowledge necessitated by a growing and changing industry. Because the competition and skill requirements for jobs are greater than ever, students in industrial vocational programs must receive the best education possible to actively compete effectively in today's market.

This guide, Fluid Power/Basic Hydraulics, has been written to assist industrial vocational instructors who are attempting to help their student meet this challenge. A second guide Basic Pneumatics, which compliments this guide is also available. Two additional guides Fluid Power Systems Maintenance and Operation and Fluid Power Systems Designs and Modification are in the process of being written.

Suggested student reading assignment that are referenced in this guide are directed to the following textbook: John Deere - Fundamentals of Service - Hydraulics FOS 1003B. John Deere and Company also has student workbooks and 35mm color slide sets available to assist the instructor in presenting the material. The Instructional Materials Laboratory, #10 Industrial Education Building, Columbia, Missouri 65211, has Living with the Metric System available for those curriculums requiring metrics.

An advisory committee composed of various industrial vocational instructors, representatives from community colleges, representatives from industry, and state department personnel were instrumental in the developing and writing of this Fluid Power/Basic Hydraulics curriculum guide.

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FLUID POWER/BASIC HYDRAULICS

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Competency Profile

HOW TO USE THIS GUIDE

This guide contains the instructional analysis which lists the information and demonstration lessons for the course. A competency profile is also included which provides a checklist of the major competency areas to be achieved by each student plus a certificate of recognition. This profile provides a permanent record for student, instructor, and/or industry representatives to present or review when determining student competencies. Each instructional unit contains both informational and demonstration lessons. Lessons are planned for one class period of instruction; however, adjustments will need to be made to adapt to individual situations.

The information lessons include a title page, outline (key points), transparency masters, interaction items (review points), assignment sheet, and evaluation items. The demonstration (skill) lessons include a title page, steps of procedure (operations), interaction items, and evaluation items.

INFORMATION LESSON COMPONENTS

Title Page: (White; instructor only)

1. Objectives: Each unit of instruction is based on behavioral objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Behavioral objectives are stated in two forms, 1) the scope of unit states the subject matter to be covered in each unit of instruction, and 2) the lesson objective states the student performance necessary to reach the unit objective.

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit. Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When a teacher adds objectives, the needed information sheets, assignment sheets, and evaluation items should be added also.

2. Supplementary Teaching/Learning Items: This is a list of transparency masters, assignment sheets and handouts prepared for this lesson.
3. Informational Assignment: This identifies reading assignments for the student. Assignments are given in chapters or units rather than pages to accommodate the change of textbook editions.
4. References: Additional information is listed here which would be helpful to the instructor. Space is provided for the instructor to list his/her own sources. This allows the instructor to assemble materials quickly when needed for presentation, review, or revision of the lesson.
5. Introduction: This is a short, precise statement describing the importance of the lesson. It addresses the question of "How do I get my students set in a

frame of mind to pay attention to the lesson?" This statement should be motivational to help the student establish the meaning of the lesson.

Outline (Key Points): (Yellow; instructor and student)

These sheets provide content essential for meeting the cognitive (knowledge) objectives of the units. The teacher will find that information sheets serve as excellent guides for presenting the background knowledges necessary to develop the skills specified in the unit objectives.

Student should read these sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparencies (TM), assignment sheets (AS), and handouts (HO) are keyed to the outline for proper use.

Transparency Masters: (White; instructor and student)

Transparency masters provide information in a special way. The students may see as well as hear the material presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective for such activities as identifying and locating the parts of construction and equipment used.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion. The transparency masters also serve as a source for the instructor to make his/her own handouts for distribution to the class. In fact many of the transparency masters in this guide, especially those containing fine print or a lot of information, are best handled, at the instructor's discretion, in this manner. An attempt was made not to duplicate a transparency master as a separate handout.

Interaction Items: (Blue; instructor only)

This sheet which is prepared for the instructor only helps in the planning of verbal involvement with students over the lesson content. Key points about the lesson are listed in question form in order to obtain feedback. These questions may then be used at anytime during the lesson as a quick check of student comprehension and to call attention to key points.

Classroom, laboratory, shop, or other activities are listed at the bottom of this page. Activities should be planned to follow each lesson presentation. This provides a means of reinforcing a desired level of learning.

Assignment Sheets: (Buff; instructor and student)

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop knowledge which is a necessary prerequisite to skill development. These may be given to the student for completion in class or used for homework assignments. Students will need to study the assigned readings because not all of the answers can be found on the key points outline.

Evaluation Items: (Pink; instructor and student)

Paper and pencil evaluations have been constructed to measure student achievement of each objective listed in the lesson. Teachers are encouraged to construct and add questions of their own to the test. Answers are provided on the instructor's copy only to aid in grading.

DEMONSTRATION (SKILL) LESSON COMPONENTS

Title Page and Interaction Items:

(These components are the same for the information and demonstration lessons. See explanation under information lesson components for further details.)

Steps of Procedure (Operations): (Green; instructor and student)

This component is designed for use in an operating (on-job) situation. The instructor should demonstrate the skills outlined on this sheet. Procedures outlined on this sheet give direction to the skill being taught and allow both student and instructor to check student progress toward the accomplishment of the skill. This component provides a ready outline for a student to follow if a demonstration has been missed.

Evaluation Items: (Pink; instructor and student)

This sheet contains a condensed check list for each of the steps of procedure (operations) included in this lesson. Appropriate space has been allowed for the instructor to check "yes" or "no" as to the student's performance. The instructor is encouraged to add any additional comments as this sheet becomes a permanent record of a student's capabilities and can be used for future reference.

COMPETENCY CERTIFICATE

This certificate is in the back of this curriculum guide. It is a compilation of the tasks performed in the Demonstration Lessons. It provides the student and instructor with a permanent record of the student's achievements in this Fluid Power/Basic Hydraulics Guide.

FLUID POWER/BASIC HYDRAULICS

Demonstration

Information

ORIENTATION TO FLUID POWER/HYDRAULICS

1. Introduction to Fluid Power/Hydraulics
2. Fundamentals of Fluid Power/Hydraulics
3. Basic Hydraulic Circuits
4. Service a Hydraulic Jack

COMPONENTS

5. Reservoirs
6. Clean and Inspect Vented Reservoir
7. Lines, Fittings, and Couplers
8. Replace a Reusable Hose End
9. Seals
10. Install an O-ring
11. Install a Mechanical Seal
12. Filters
13. Hydraulic Fluids
14. Introduction to Pumps
15. Pump Operation
16. Disassemble, Inspect, and Reassemble a Gear Pump
17. Disassemble, Clean and Inspect, and Reassemble a Pressure Compensated Variable Displacement Pump

Demonstration

Information

-
-
19. Disassemble, Inspect, and Reassemble a Directional Control Valve

18. Introduction to Hydraulic Valves

20. Cylinders

21. Hydraulic Motors

22. Hydraulic Accessories

LESSON PLAN: 1

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

SCOPE OF UNIT:

After completion of this unit, the student should be able to discuss the advantages and disadvantages of hydraulics, name potential safety hazards of hydraulic systems, and list safety practices when working on hydraulic systems. The student should be able to discuss the four functions of hydraulic fluids and select true statements concerning the power transfer in a hydraulic system. The student should also be able to identify the components of a basic hydraulic circuit and jack and to disassemble, clean, inspect and reassemble a hydraulic jack. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets by scoring 85 percent on the evaluation items.

INFORMATION TOPIC: I-1

INTRODUCTION TO FLUID POWER/HYDRAULICS
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Match terms associated with fluid power/hydraulics.
2. Select systems which utilize hydraulics.
3. List advantages and disadvantages of hydraulics.
4. Name six hazards to safety when working with hydraulic systems.
5. List five safety practices when working on hydraulic systems.
6. List six safety and environmental organizations involved in setting standards and regulations for hydraulic usage.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

INFORMATIONAL ASSIGNMENT: (Student)

Study the outline on the following pages prior to class time and be ready to discuss.

REFERENCES: (Instructor's Additional Information)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979.

Pippinger, John J. and Tyler G. Hicks. Industrial Hydraulics. Dallas: Gregg Division/McGraw-Hill Book Company, 1979.

INTRODUCTION:

People have been using fluids to aid them in their work for many years. As technology has advanced, so has the use of fluids. The use of hydraulics is one of today's most popular working tools.

LESSON PLAN: 1

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

INFORMATION TOPIC: I-1

OUTLINE: (Key Points)

I. Terms and definitions

- A. **Hydraulics** - the study of liquids in motion or at rest
- B. **Fluid power** - the use of liquids and/or gases under pressure to perform work
- C. **Work** - the transfer of energy from one physical system to another
- D. **Power** - strength or force exerted or capable of being exerted
- E. **Liquid** - a fluid which is relatively incompressible
- F. **Gas** - a gas is a fluid that is highly compressible.

II. Systems which utilize hydraulics

(NOTE: There are many systems which utilize hydraulic power. The following are some of the applications on different types of machinery.)

A. Mobile Equipment

- 1. Hitch control

(NOTE: Hitch controls can be found on agricultural tractors.)

- 2. Backhoe

(NOTE: A backhoe is a commonly used piece of construction equipment.)

- 3. Power steering

(NOTE: Power steering systems are commonly used on automobiles, trucks, construction equipment, and agricultural equipment.)

- 4. Brakes

(NOTE: Hydraulic brakes can be found on automobiles, trucks, construction equipment, and agricultural tractors.)

B. Machine tools

1. Numerically controlled machine
2. Industrial robot

C. Auxiliary controls and actuators

D. Material handling

III. Advantages and disadvantages of hydraulics

A. Advantages

1. Flexibility - allows a flexible transfer of large forces
2. Multiplication of force - small forces can be used to control large forces
3. Simplicity
 - a. Has fewer moving parts and points of wear than a mechanical system
 - b. Is able to lubricate itself
4. Compactness - hydraulic motors are more compact than electrical motors of equal horsepower
5. Economy
 - a. Long service life
 - b. Low operating cost
 - c. Low maintenance
6. Safety - hydraulic systems have fewer moving parts and present fewer potential hazards than mechanical systems with gears and chains. Free from electromagnetic resistance; nonexplosive.

B. Disadvantages

1. Safety - high pressure is potentially dangerous
2. Cleanliness - system must be kept very clean to prevent excessive wear of the components
3. Contamination or corrosiveness of system components

IV. Safety hazards when working with hydraulic systems

- A. Components subjected to excessive pressure may fracture.

- B. Accidental release of trapped oil in hydraulic circuits supporting booms or attachments may cause these components to malfunction or fall suddenly.
 - C. Hot oil from leaks, disconnected lines, or reservoir drains can cause severe burns.
 - D. Pin-hole leaks in high pressure circuits can release potentially dangerous fluids.
 - E. Some hydraulic fluids are flammable.
 - F. Some hydraulic fluids can irritate or burn when they come in contact with the skin or eyes.
- V. Safety practices when working on hydraulic systems
- A. Support booms and attachments before working on a hydraulic system.
 - B. Operate all control levers to insure hydraulic pressure has been relieved.
 - C. Loosen lines and components in a circuit slowly to relieve trapped pressure.
 - D. Stop equipment and repair leaks immediately.
 - E. Observe normal shop safety practices including the wearing of safety glasses and safety helmets.
- VI. Safety and environmental organizations involved in setting standards and regulations for hydraulics usage
- A. ISO (International Standards Organization) - disposal of oil, labeling, hazard warnings, sets manufacturing specifications
 - B. OSHA (Occupational Safety and Health Administration) - labeling, hazard warnings, sets manufacturing specifications
 - C. EPA (Environmental Protection Agency) - disposal of oil
 - D. DOT (Department of Transportation) - labeling, hazard warnings, sets manufacturing specifications for use in the transportation industry
 - E. State - labeling, hazard warnings, disposal of oil
 - F. Local - disposal of oil

(NOTE: State and local agencies are required to meet minimum federal standards but can exceed them.)

LESSON PLAN: 1

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

INFORMATION TOPIC: I-1

INTERACTION ITEMS:

1. How dangerous are pin-hole leaks in high pressure circuits?
2. What equipment utilizes fluid power/hydraulics at our facility?

CLASSROOM, SHOP, LABORATORY, OR OTHER ACTIVITIES:

1. Show examples of different types of systems which utilize hydraulics.
2. Demonstrate hazards that can occur when working with hydraulic systems.
3. Demonstrate safety procedures which should be practiced when working with hydraulics.

LESSON PLAN: 1

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

INFORMATION TOPIC: I-1

EVALUATION ITEMS:

1. Match terms with correct definitions.

- | | | |
|-----------------------------|--|----------------|
| ☐ a. | The transfer of energy from one physical system to another | 1. Fluid power |
| ☐ b. | The use of liquids and/or gases under pressure to perform work | 2. Hydraulics |
| ☐ c. | A fluid which is relatively incompressible | 3. Power |
| ☐ d. | The study of liquids in motion or at rest | 4. Work |
| ☐ e. | A fluid that is highly compressible | 5. Liquid |
| ☐ f. | Strength or force exerted or capable of being exerted | 6. Gas |

2. Select systems which utilize hydraulics by placing an "x" in the appropriate blanks.

- ☐ a. Brakes
- ☐ b. Power steering
- ☐ c. Material handling equipment
- ☐ d. Mechanical differential
- ☐ e. Machine tools

3. List four advantages and three disadvantages of hydraulics.

a. Advantages

1.

2.

3.

4.

b. Disadvantages

1.

2.

3.

4. Name six hazards to safety when working with hydraulic systems.

a.

b.

c.

d.

e.

f.

5. List five safety practices when working on hydraulic systems.

a.

b.

c.

d.

e.

6. List six safety and environmental organizations involved in setting standards and regulations for hydraulics usage.

a.

b.

c.

d.

e.

f.

LESSON PLAN: 1

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

INFORMATION TOPIC: I-1

ANSWERS TO EVALUATION ITEMS:

1.
 - a. 4
 - b. 1
 - c. 5
 - d. 2
 - e. 6
 - f. 3
2. a, b, c, e
3. Discussion should include four of the following advantages and the two disadvantages
 - a. Advantages
 - 1) Flexibility - allows a flexible transfer of large forces
 - 2) Multiplication of force - small forces can be used to control large forces
 - 3) Simplicity
 - a) Has fewer moving parts and points of wear than a mechanical system
 - b) Is able to lubricate itself
 - 4) Compactness - hydraulic motors are more compact than electrical motors of equal horsepower
 - 5) Economy
 - a) Long service life
 - b) Low operating cost
 - c) Low maintenance

- 6) Safety - hydraulic systems have fewer moving parts and present fewer potential hazards than mechanical systems with gears and chains
- b. Disadvantages
 - 1) Safety - high pressure is potentially dangerous
 - 2) Cleanliness - system must be kept very clean to prevent excessive wear of the components
 - 3) Contamination or corrosiveness of system components
4.
 - a. Components subjected to excessive pressure may fracture.
 - b. Accidental release of trapped oil in hydraulic circuits supporting booms or attachments may cause these components to malfunction or fall suddenly.
 - c. Hot oil from leaks, disconnected lines, or reservoir drains can cause severe burns.
 - d. Pin-hole leaks in high pressure circuits can release potentially dangerous fluids.
 - e. Some hydraulic fluids are flammable.
 - f. Some hydraulic fluids can irritate or burn when they come in contact with the skin or eyes.
5.
 - a. Support booms and attachments before working on a hydraulic system.
 - b. Operate all control levers to insure hydraulic pressure has been relieved.
 - c. Loosen lines and components in a circuit slowly to relieve trapped pressure.
 - d. Stop equipment and repair leaks immediately.
 - e. Observe normal shop safety practices including the wearing of safety glasses and safety helmets.
6.
 - a. ISO
 - b. OSHA
 - c. EPA
 - d. DOT
 - e. State
 - f. Local

LESSON PLAN: 2

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

SCOPE OF UNIT:

After completion of this unit, the student should be able to discuss the advantages and disadvantages of hydraulics, name potential safety hazards of hydraulic systems, and list safety practices when working on hydraulic systems. The student should be able to discuss the four functions of hydraulic fluids and select true statements concerning the power transfer in a hydraulic system. The student should also be able to identify the components of a basic hydraulic circuit and jack and to disassemble, clean, inspect and reassemble a hydraulic jack. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment and job sheets and by scoring 85 percent on the evaluation items.

INFORMATION TOPIC: 1-2

FUNDAMENTALS OF FLUID POWER/HYDRAULICS
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Match terms associated with fundamentals of hydraulics with the correct definitions.
2. Discuss briefly four functions of hydraulic fluids.
3. Calculate pressure when given force and area.
4. State Pascal's law.
5. Explain the operating principles of a hydraulic press.
6. Discuss Bernoulli's theorem.
7. Discuss Boyle's law.
8. State Charles' law.
9. Discuss the law of conservation of energy.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Calculation of Hydraulic Pressure
2. TM 2: Pascal's Law
3. TM 3: Basic Hydraulic Press
4. TM 4: Bernoulli's Theorem
5. TM 5: Law of Conservation
6. TM 6: States of Energy
7. TM 7: Changing Energy States
8. TM 8: Forms of Energy

INFORMATIONAL ASSIGNMENT: (Student)

REFERENCES: (Instructor's Additional Information)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979.

Industrial Hydraulics Manual. Troy, MI: Sperry Rand Corporation, 1970.

Fluid Power I. Cleveland, OH: Parker-Hannifan Corporation, 1979.

INTRODUCTION:

In spite of the flexibility of hydraulics, some principles remain constant. We will now study some of these principles, including Pascal's law, Boyle's law, Charles' law, the law of conservation of energy, and other formulas for calculating fluid power/hydraulics.

LESSON PLAN: 2

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

INFORMATION TOPIC: I-2

OUTLINE: (Key Points)

I. Terms and definitions

- A. **Energy** - the ability or capacity to do work
- B. **Fluid** - a substance which has no shape of its own
- C. **Pressure** - the force divided by its area of application
- D. **Liquid** - a fluid which is relatively incompressible

II. Functions of hydraulic fluids

- A. **Power transmission** - provides a medium for transferring force from one location to another
- B. **Lubrication** - lessens friction on internal surfaces of hydraulic system components in order to reduce wear
- C. **Sealing** - reduces flow through leakage paths
- D. **Cooling** - provides a medium for removing heat generated in the system

III. Pascal's law - pressure on a confined fluid is transmitted undiminished in all directions at right angles to the surface of the containing vessel (TM 2)

(NOTE: $P =$)

IV. Calculation of pressure (TM 1)

- A. Determine force.

(NOTE: Newton's law)

- B. Determine area of surface to which force is applied.

(NOTE: $A = r^2$)

- C. Divide force by area of surface to which force is applied. Pressure is normally measured in units of pounds per square inch (psi). Therefore, the force should be expressed in units of pounds, and area should be expressed in square inches.

Example: If the force is 4 pounds and the area equals 2 square inches, then the pressure will be 2 psi.

V. Operating principles of a simple hydraulic press and/or hydraulic jack (TM 3)

(NOTE: The operation of a simple hydraulic press (jack) is an example of the application of Pascal's law.)

- A. A simple hydraulic press consists of two pistons supported by a quantity of hydraulic fluid.
- B. A force on one piston creates a pressure in the hydraulic fluid equal to the force divided by the piston area.
- C. Pascal's law states the pressure will be equal at all points within the fluid including the fluid at the second piston.
- D. The force applied by the second piston is equal to the pressure times the area of the second cylinder.

(NOTE: This is an example of force multiplication in a hydraulic system.)

VI. Bernoulli's theorem (TM 4)

(NOTE: The following discussion does not take into account friction loss in the pipe.)

- A. Fluid flowing in a pipe will have flow rate and pressure.
- B. Where the cross-sectional area of the pipe decreases, then the pressure will decrease.

(NOTE: The flow rate will increase.)

- C. If the cross-sectional area increases to its original size, then the pressure will return to its original value.

(NOTE: The flow rate will also return to its original value.)

VII. Boyle's law - a gaseous mass can be compressed and its volume is inversely proportional to the pressure on it, as long as the temperature stays the same.

(NOTE: This law is a governing factor in engine design, relative to piston displacement and compression ratio.)

VIII. Charles' law - temperature changes on a gaseous mass result in direct changes of volume at a constant pressure.

(NOTE: Boyle's law and Charles' law are very closely related.)

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

IX. Law of conservation of energy - energy can neither be created nor destroyed, although it may change from one form to another. (TM 5)

A. Energy can be found in two states (TM 6)

1.  Kinetic state - moving energy

2.  Potential state - stored energy

B. Energy can change states (TM 7)

C. Forms of energy (TM 8)

1. Electrical

2. Mechanical

3. Heat

4. Light

5. Sound

6. Chemical

LESSON PLAN: 2

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

INFORMATION TOPIC: 1-2

INTERACTION ITEMS:

1. Calculate pressure using the following information.
 - A. Force = 50 lbs.
Area = 5 sq. in.
 - B. Force = 10 lbs.
Area = 2 sq. in.
2. Apply Bernoulli's theory to your city's water system.
3. Apply Boyle's law to the gasoline engine.

CLASSROOM, SHOP, LABORATORY, OR OTHER ACTIVITIES:

LESSON PLAN: 2

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1: ORIENTATION TO FLUID POWER/HYDRAULICS

INFORMATION TOPIC: 1-2

EVALUATION ITEMS:

1. Match the terms on the right with the correct definitions.

- | | | |
|--------|--|-------------|
| ___ a. | A substance which has no shape of its own | 1. Fluid |
| ___ b. | The force exerted on a surface divided by its area | 2. Liquid |
| ___ c. | A fluid which is relatively incompressible | 3. Pressure |
| ___ d. | A force which can cause a body to move | 4. Energy |

2. Discuss briefly four functions of hydraulic fluids.

- a.
- b.
- c.
- d.

3. Calculate pressure in the following problems when given area and force.

- a. Force = 100 lbs, Area = 10 square inches
- b. Force = 10 lbs, Area = 1 square inch
- c. Force = 5 lbs, Area = 1/2 square inch

4. State Pascal's law.

5. Explain the operating principles of a hydraulic press.

a.

b.

c.

d.

6. Discuss Bernoulli's theorem.

a.

b.

c.

7. Discuss Boyle's law.

8. State Charles' law.

9. Discuss the law of conservation of energy.

a.

b.

c.

LESSON PLAN: 2

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1: ORIENTATION TO FLUID POWER/HYDRAULICS

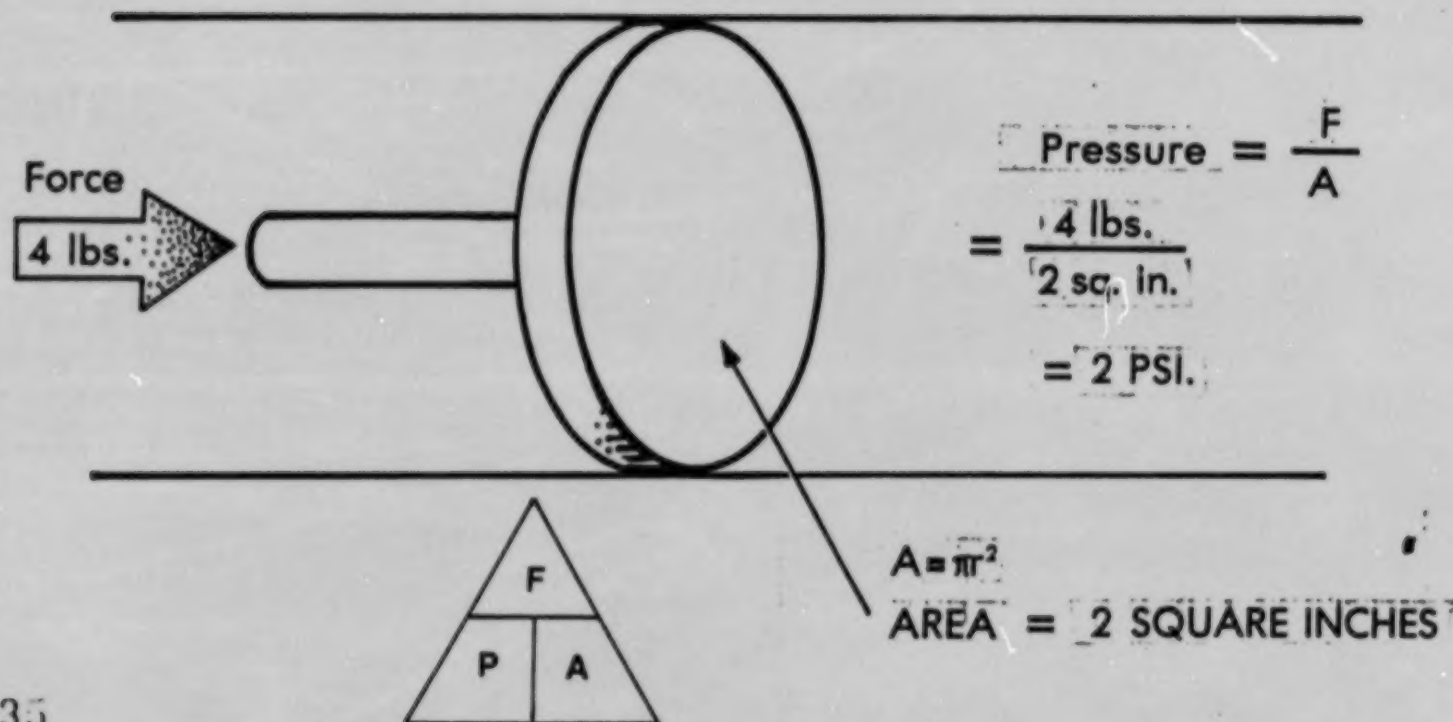
INFORMATION TOPIC: I-2

ANSWERS TO EVALUATION ITEMS:

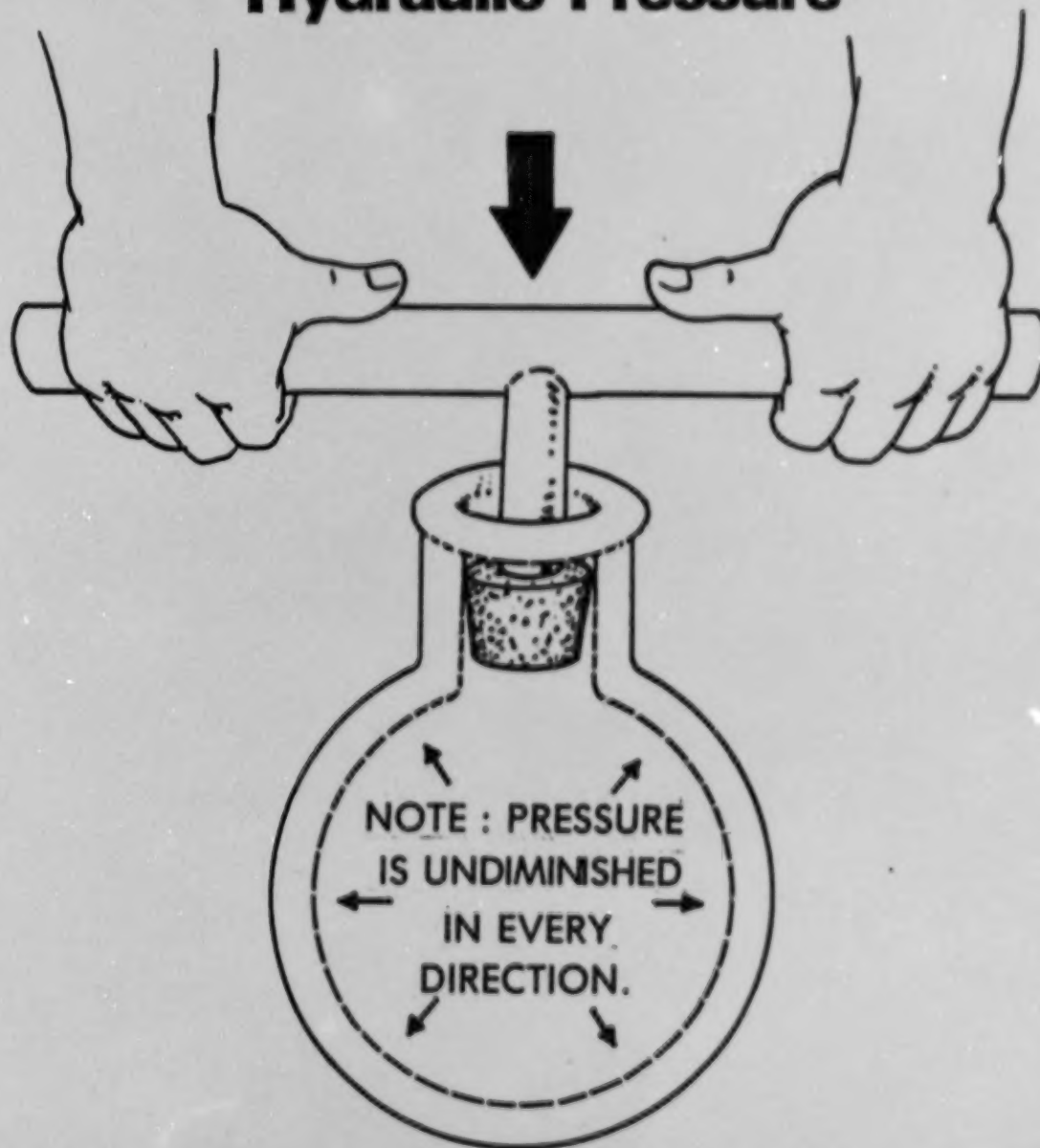
1.
 - a. 1
 - b. 3
 - c. 2
 - d. 4
2. Discussion should include:
 - a. Power transmission - provides a medium for transferring force from one location to another.
 - b. Lubrication - lessens friction on internal surfaces of hydraulic system components in order to reduce wear.
 - c. Sealing - reduces flow through leakage paths.
 - d. Cooling - provides a medium for removing heat generated in the system.
3.
 - a. 10 psi
 - b. 10 psi
 - c. 10 psi
4. Pressure on a confined fluid is transmitted undiminished in all directions at right angles to the surface of the containing vessel.
5. Explanation should include:
 - a. A hydraulic press consists of two pistons supported by a quantity of hydraulic fluid.
 - b. A force on one piston creates a pressure in the hydraulic fluid equal to the force divided by the piston area.
 - c. Pascal's law states the pressure will be equal at all points within the fluid including the fluid at the second piston.
 - d. The force applied by the second piston is equal to the pressure times the area of the second cylinder.

6. Discussion should include:
 - a. Fluid flowing in a pipe will have some pressure and flow rate
 - b. If the cross-sectional area of the pipe decreases, then the pressure will decrease.
 - c. If the cross-sectional area increases to its original size, then the pressure will return to its original value.
7. Discussion should include:
 - a. Gas mass can be compressed.
 - b. Its volume is inversely proportional to the pressure on it, if the temperature remains the same.
8. Charles' Law - temperature changes on a gaseous mass result in direct changes of volume and pressure.
9. Discussion should include:
 - a. Energy can be found in two states - kinetic and potential.
 - b. Energy can change states - kinetic to potential or vice versa.
 - c. Forms of energy - electrical, mechanical, heat, light, sound, and chemical

Calculation of Hydraulic Pressure



Hydraulic Pressure



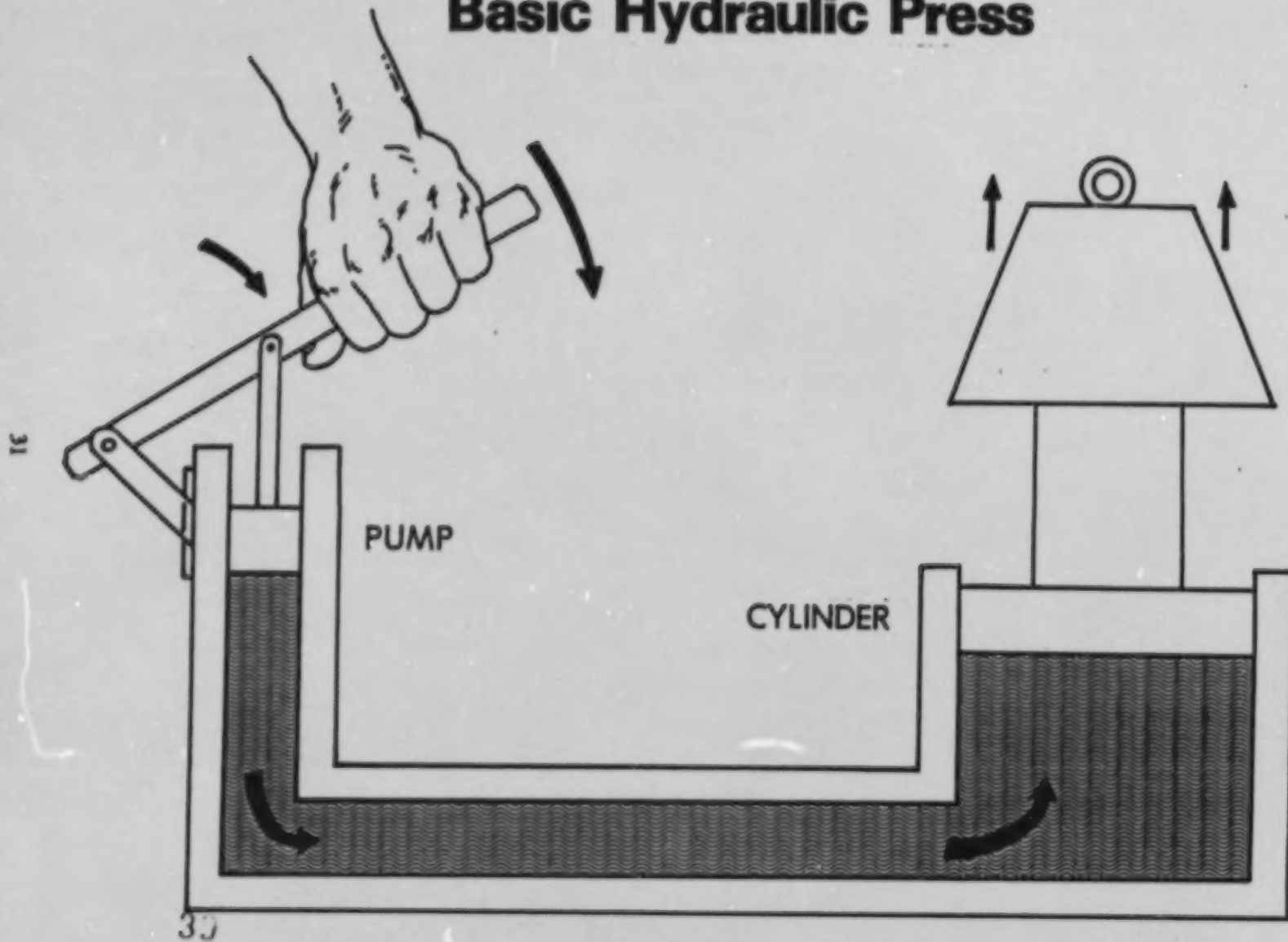
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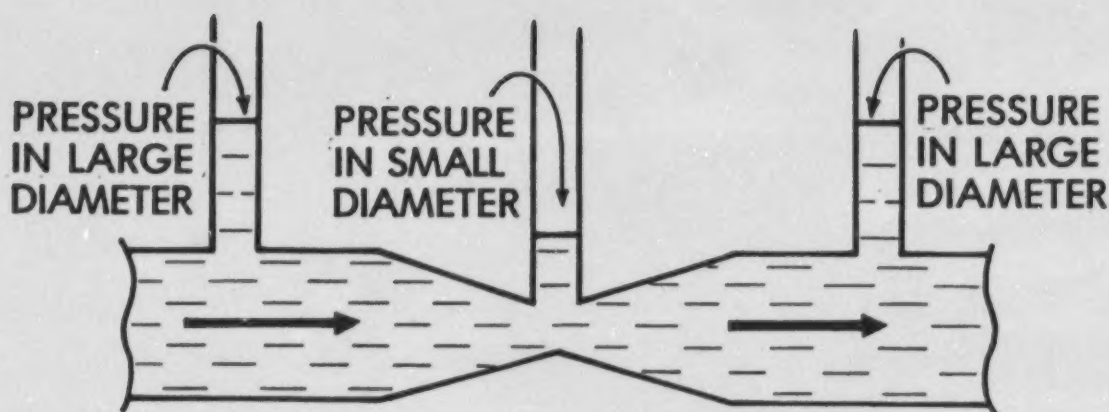
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TM 2

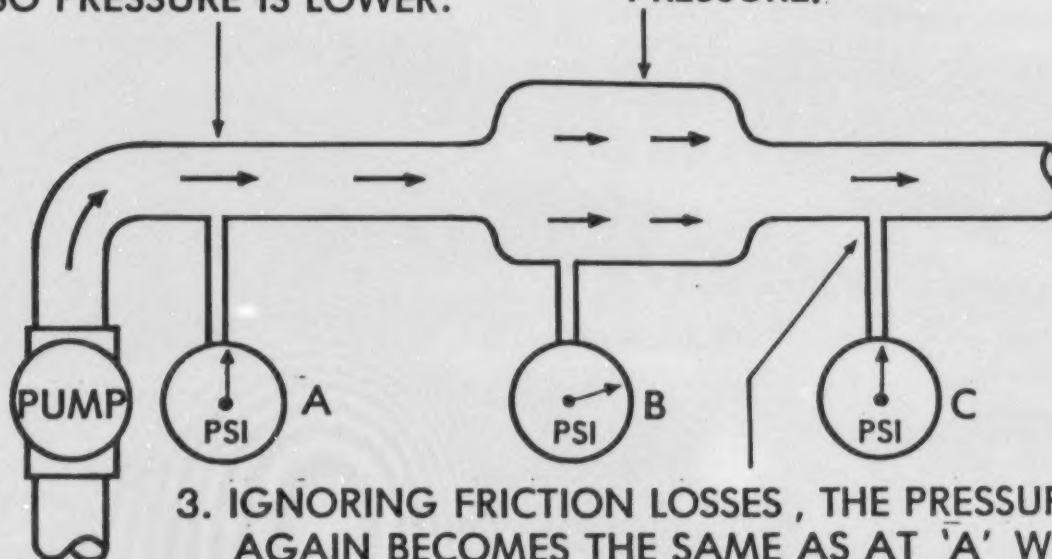
Basic Hydraulic Press



Bernoulli's Theorem



1. IN THE SMALL SECTION PIPE, VELOCITY IS MAXIMUM. MORE ENERGY IS IN THE FORM OF MOTION, SO PRESSURE IS LOWER.
2. VELOCITY DECREASES IN THE LARGER PIPE. THE KINETIC ENERGY LOSS IS MADE UP BY AN INCREASE IN PRESSURE.

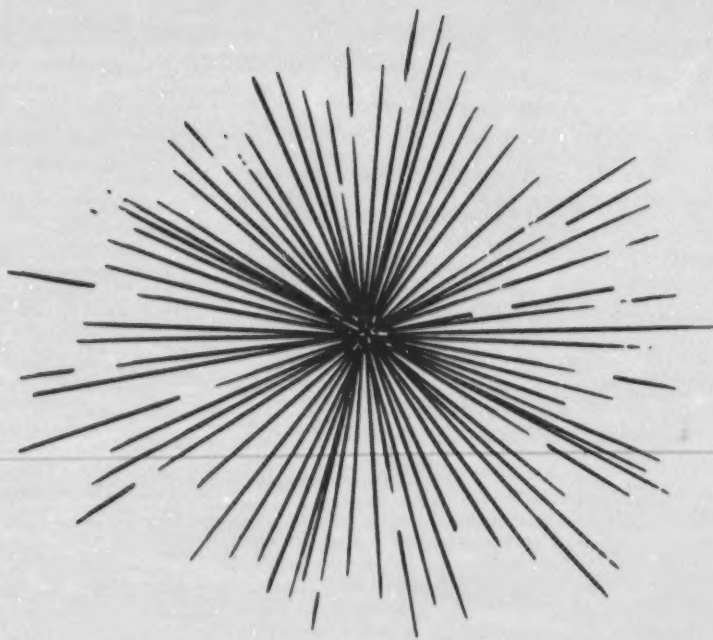


3. IGNORING FRICTION LOSSES, THE PRESSURE AGAIN BECOMES THE SAME AS AT 'A' WHEN THE FLOW VELOCITY BECOMES THE SAME AS AT 'A'.

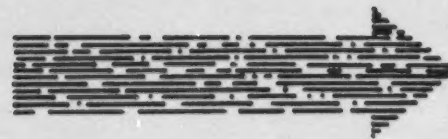
The Law of Conservation



States of Energy



Potential Energy



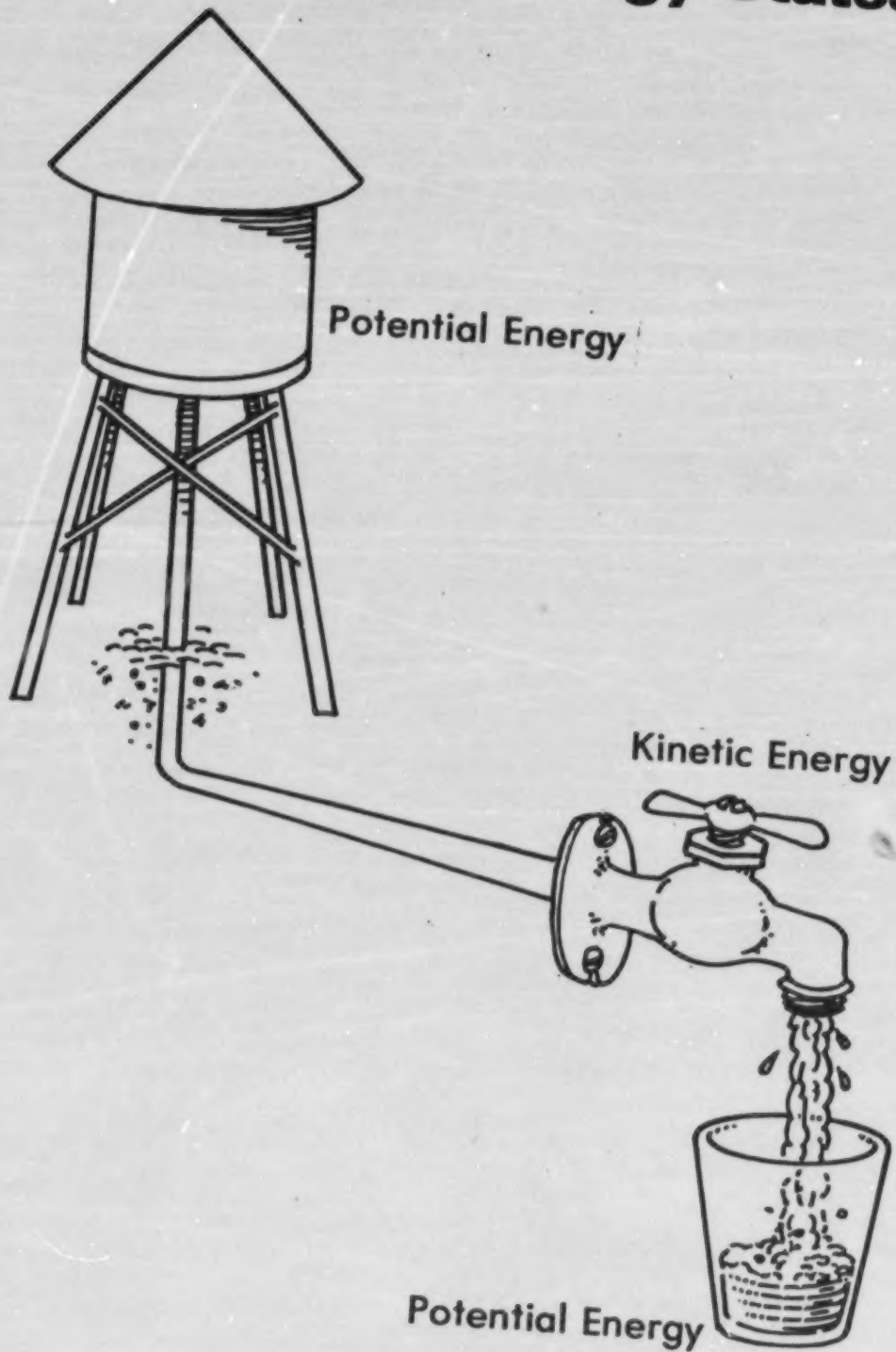
Kinetic Energy

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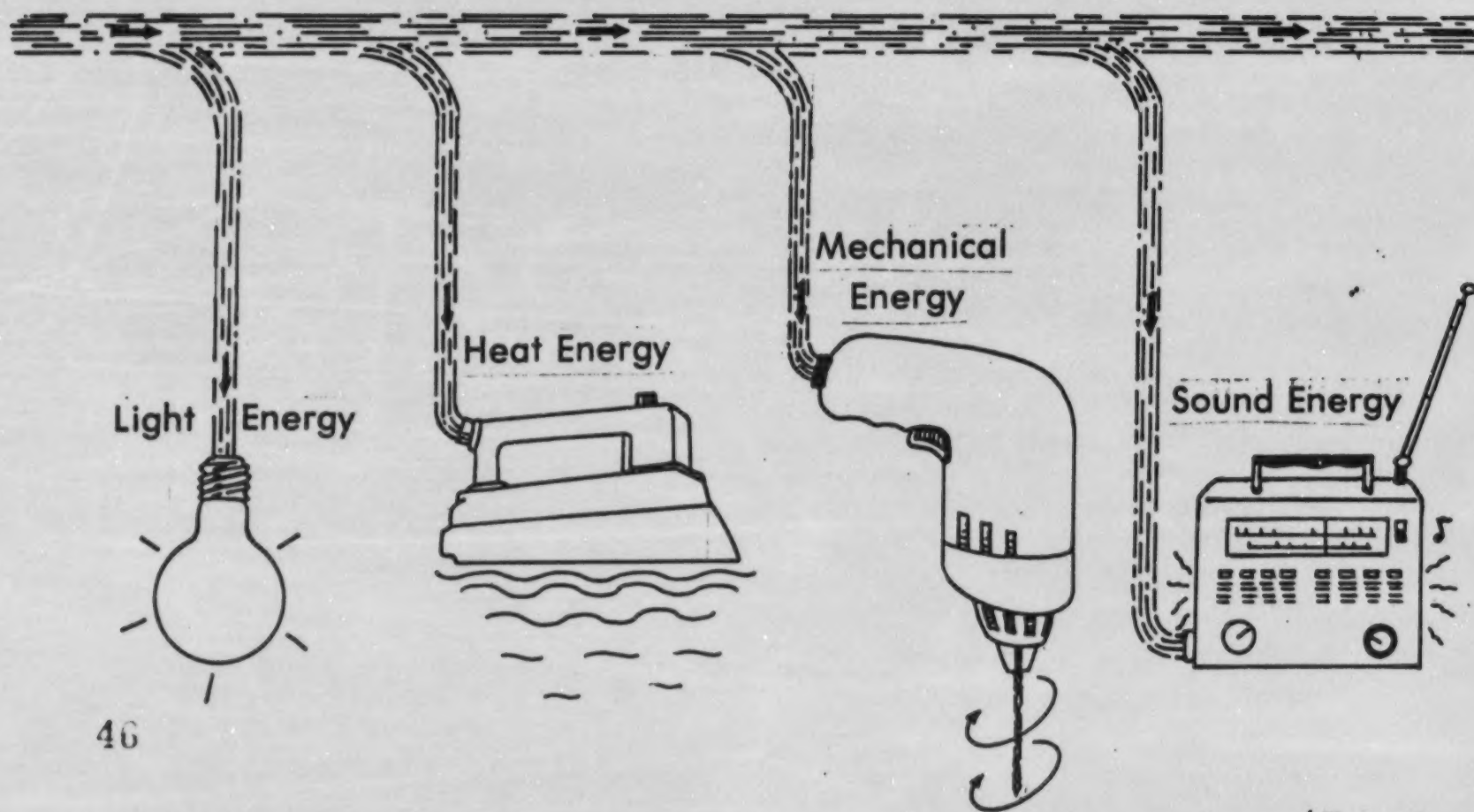
43

44

Changing Energy States



Forms of Energy



46

47

TM 8

LESSON PLAN: 3

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

SCOPE OF UNIT:

After completion of this unit, the student should be able to discuss the advantages and disadvantages of hydraulics, name potential safety hazards of hydraulic systems, and list safety practices when working on hydraulic systems. The student should be able to discuss the four functions of hydraulic fluids and select true statements concerning the power transfer in a hydraulic system. The student should also be able to identify the components of a basic hydraulic circuit and jack and to disassemble, clean, inspect and reassemble a hydraulic jack. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment and job sheets and by scoring 85 percent on the evaluation items.

INFORMATION TOPIC: 1-3

BASIC HYDRAULIC CIRCUITS
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Identify the components of a basic hydraulic circuit.
2. Select true statements concerning the power transfer in a hydraulic system.
3. Identify the components of a hydraulic jack.
4. Distinguish between the lifting and lowering of a hydraulic jack.
5. Draw a block diagram of a simple hydraulic system.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Block Diagram of Hydraulic System
2. TM 2: Operation of a Hydraulic Jack
3. AS 1: Draw a Block Diagram of a Simple Hydraulic System

INFORMATIONAL ASSIGNMENT: (Student)

REFERENCES: (Instructor's Additional Information)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979.

Industrial Hydraulics Manual. Troy, MI: Sperry Rand Corporation, 1970.

INTRODUCTION:

Hydraulics without flow control, pressure control, actuators, and pumps would be of little use. Proper placement in the system makes the system function correctly.

LESSON PLAN: 3

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

INFORMATION TOPIC: 1-3

OUTLINE: (Key Points)

I. Components of a simple hydraulic circuit (TM 1)

- A. Reservoir
- B. Pump
- C. Lines
- D. Valves
- E. Actuators
 - 1. Motor
 - 2. Cylinder

II. Energy transfer in a hydraulic system

(NOTE: Energy is never lost; it changes form.)

- A. Energy is supplied into pump from:
 - 1. Electric motor.
 - 2. Gasoline or diesel engine.
 - 3. Manual.
- B. Mechanical energy is converted to hydraulic power by the pump.
- C. Hydraulic energy is transmitted by lines.
- D. Hydraulic energy is regulated by valves.
- E. Hydraulic energy is converted to mechanical power by actuators.
 - 1. Motor
 - 2. Cylinder

III. Components of a hydraulic jack (TM 2)

- A. Reservoir
- B. Pump
- C. Actuator
- D. Check valve 1
- E. Check valve 2
- F. Release valve

IV. Operation of a hydraulic jack (TM 2)

A. Lifting

1. Fluid is pushed from reservoir through check valve 1 on upward stroke of hand pump.
2. Check valve 2 is closed by a spring.
3. Fluid is forced past check valve 2 to cylinder to raise object on downward stroke of hand pump.
4. Check valve 1 is closed by a spring.

B. Lowering

1. Release valve is opened to allow return of fluid to reservoir.
2. Pumping with the release valve open causes fluid to circulate from reservoir to pump, then back to reservoir.

LESSON PLAN: 3

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

INFORMATION TOPIC: 1-3

INTERACTION ITEMS:

1. What items are essential in any hydraulic circuit?
2. What item in a hydraulic jack is not normally found in a hydraulic circuit?

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

**ASSIGNMENT SHEET #1: DRAW A BLOCK DIAGRAM OF A SIMPLE
HYDRAULIC SYSTEM.**

Directions: Draw a block diagram of a simple hydraulic system showing a reservoir, pump, valves, lines, and actuator. Designate flow direction by drawing arrows in the lines.

LESSON PLAN: 3

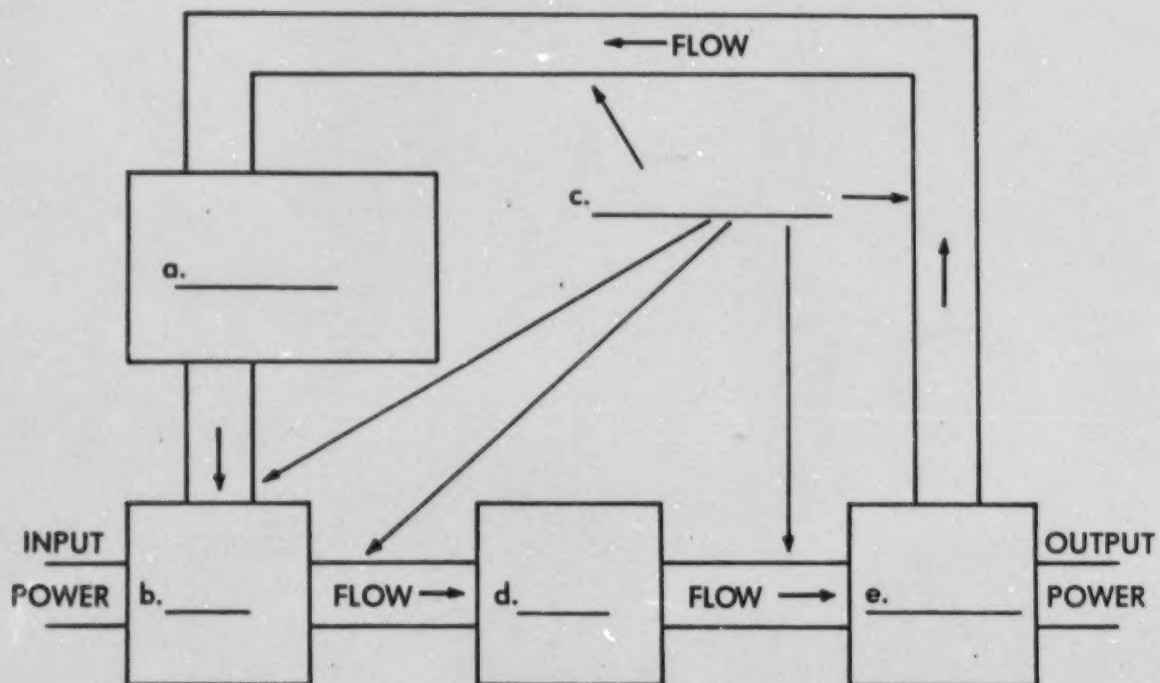
COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

INFORMATION TOPIC: 1-3

EVALUATION ITEMS:

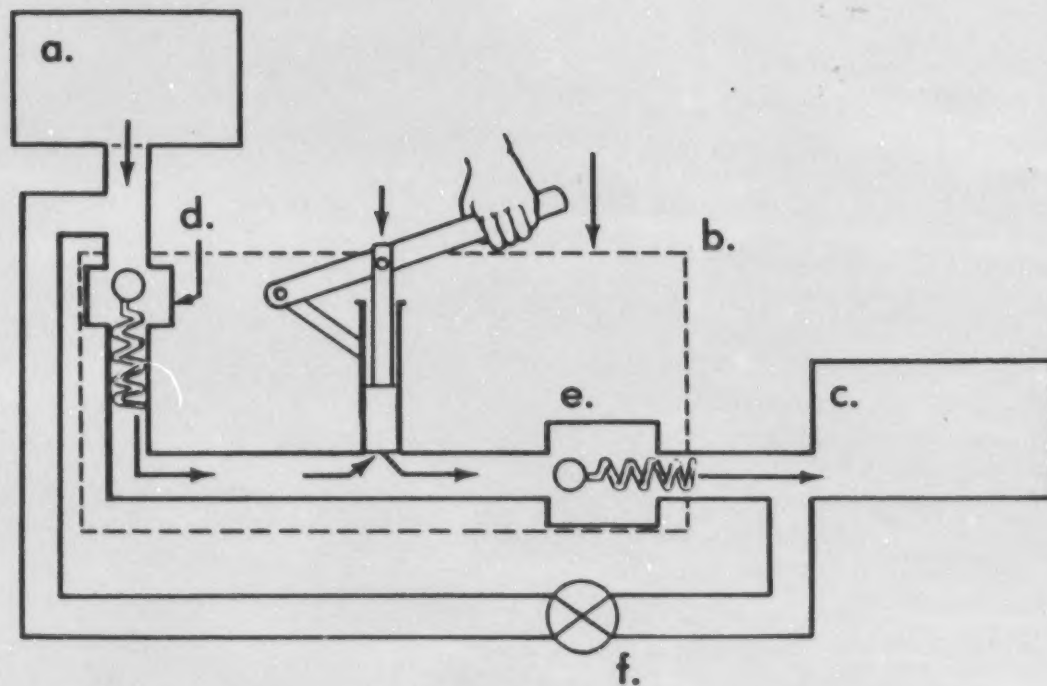
1. Identify the components of a basic hydraulic circuit in the diagram below.



2. Select true statements concerning the power transfer in a hydraulic system by placing an "X" in the appropriate blanks.

- ___ a. Power is supplied into the pump from the reservoir.
- ___ b. Mechanical power is converted to hydraulic power by the pump.
- ___ c. Hydraulic power is transmitted by lines.
- ___ d. Hydraulic power is regulated by actuators.
- ___ e. Hydraulic power is converted to mechanical power by actuators.

3. Identify the components of a hydraulic jack in the diagram below.



4. Distinguish between the lifting and lowering operation of a hydraulic jack by placing an "X" next to the description of the lowering operation.

- ___ a.
 - 1) Release valve is opened to return fluid to reservoir.
 - 2) Pumping with the release valve open causes fluid to circulate from reservoir to pump, then back to reservoir.
- ___ b.
 - 1) Fluid is pulled from reservoir through check valve 1 on upward stroke of hand pump.
 - 2) Check valve 2 is closed by a spring.
 - 3) Fluid is forced past check valve 2 to cylinder to raise object on downward stroke of hand pump.
 - 4) Check valve 1 is closed by a spring.

LESSON PLAN: 3

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

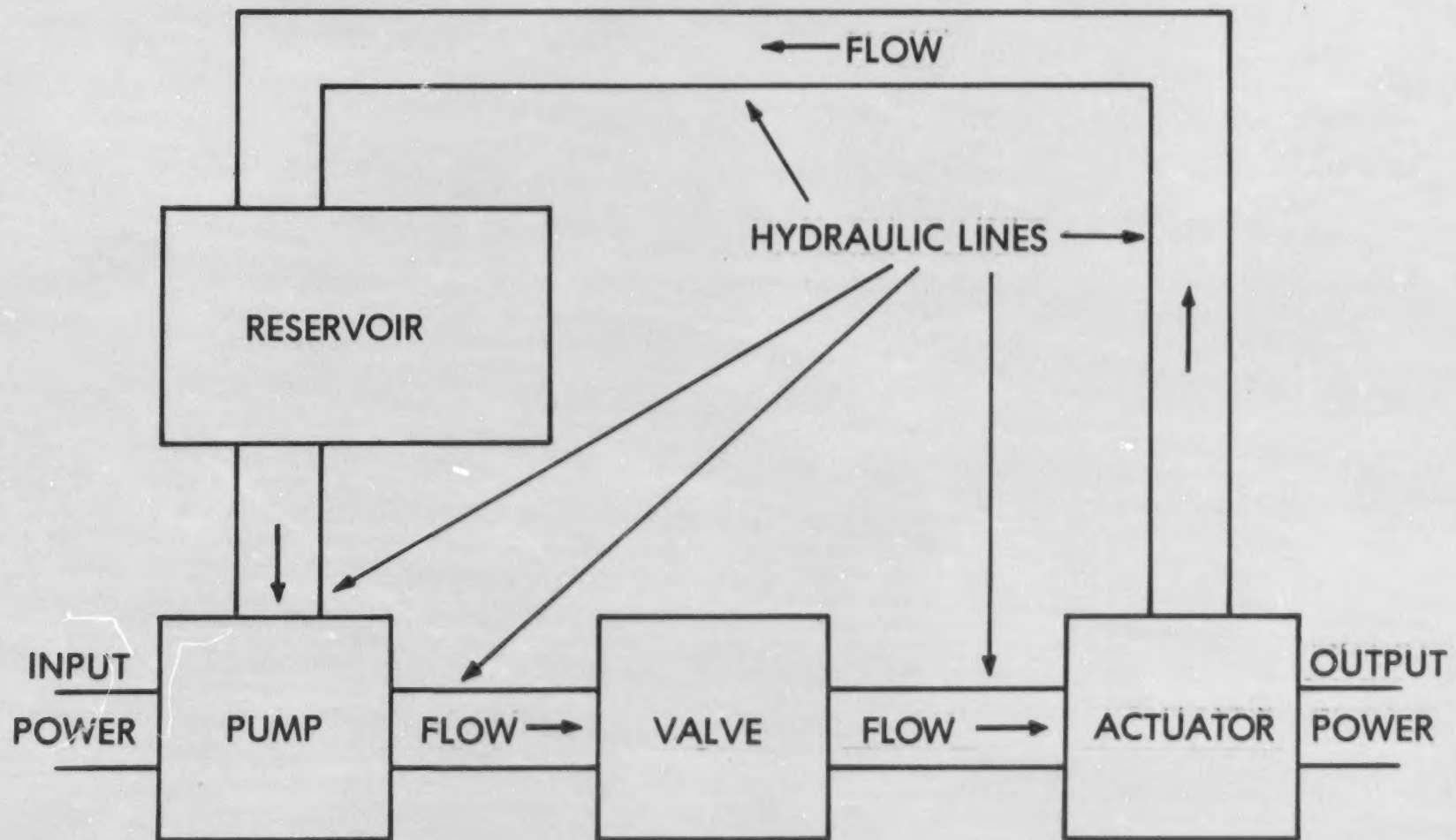
UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

INFORMATION TOPIC: I-3

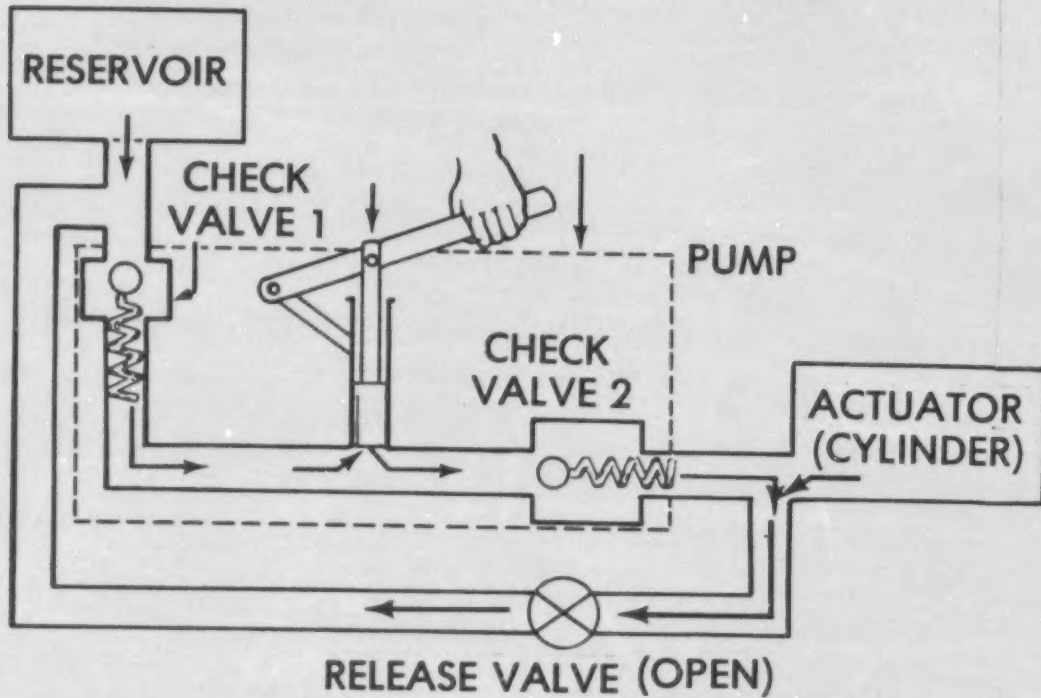
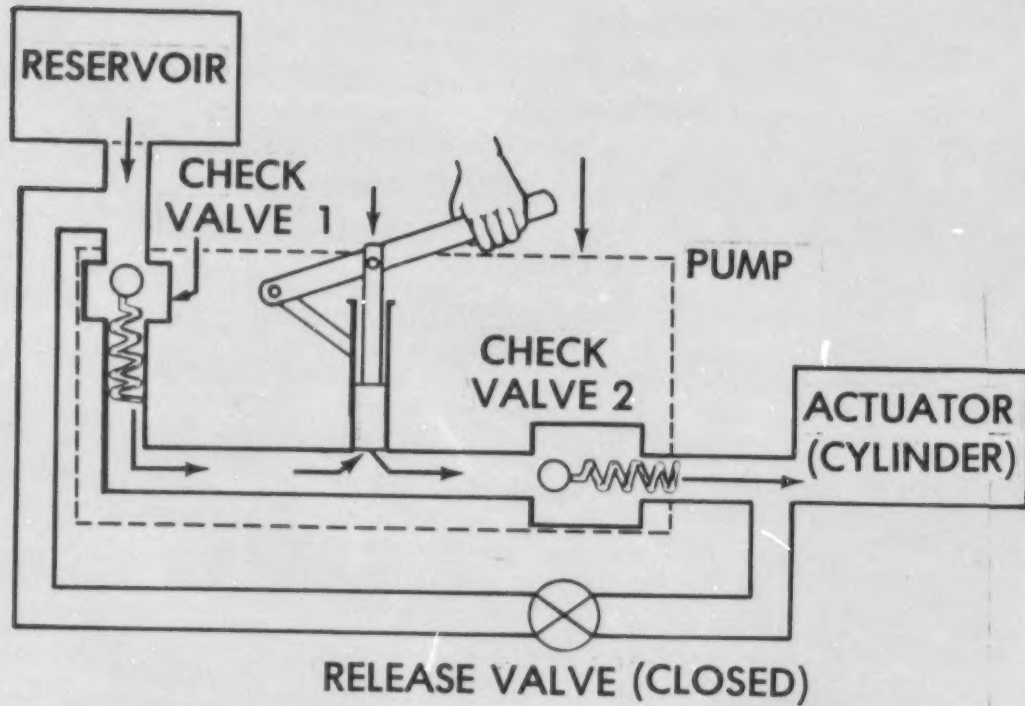
ANSWERS TO EVALUATION:

1. a. Reservoir
 b. Pump
 c. Lines
 d. Valves
 e. Actuator
2. b, c, e
3. a. Reservoir
 b. Pump
 c. Actuator
 d. Check valve 1
 e. Check valve 2
 f. Release valve
4. a

Block Diagram of Hydraulic System



Operation of a Hydraulic Jack



LESSON PLAN: 4

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT I : ORIENTATION TO FLUID POWER/HYDRAULICS

SCOPE OF UNIT:

After completion of this unit, the student should be able to discuss the advantages and disadvantages of hydraulics, name potential safety hazards of hydraulic systems, and list safety practices when working on hydraulic systems. The student should be able to discuss the four functions of hydraulic fluids and select true statements concerning the power transfer in a hydraulic system. The student should also be able to identify the components of a basic hydraulic circuit and jack and to disassemble, clean, inspect and reassemble a hydraulic jack. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment and job sheets and by scoring 85 percent on the evaluation items.

DEMONSTRATION LESSON: I-4

SERVICE A HYDRAULIC JACK
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Disassemble a hydraulic jack.
2. Clean parts of a hydraulic jack.
3. Reassemble and test a hydraulic jack.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Operation of a Hydraulic Jack (TM 2 from Unit I, Lesson Plan 3)
2. One hydraulic jack for every 2 students.

INFORMATIONAL ASSIGNMENT: (Student)

Read service literature available for jack being used in Demonstration Lesson.

REFERENCES: (Instructor's Additional Information)

Manufacturer's service manual or breakdown of parts for jack being demonstrated.

INTRODUCTION:

Applying knowledge in a hands-on application helps in complete understanding of the jack's operation.

LESSON PLAN: 4

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT I : ORIENTATION TO FLUID POWER/HYDRAULICS

DEMONSTRATION: 1-4

TOOLS, EQUIPMENT, AND MATERIALS:

Hydraulic jack (one for every 2 students)
Hand tools
Lint free shop towels
Solvent
Hydraulic fluid for jack
Vise
Safety glasses

STEPS OF PROCEDURE: (Job Sheet)

I. Disassemble

- A. Use the solvent to clean any dirt or grease from the external surfaces.
- B. Place the jack on a clean surface for disassembly.
- C. Remove the drain plug and drain oil from the jack.
- D. Remove the retaining nut which holds the ram (cylinder) in place.
- E. Remove the ram.
- F. Remove pumping piston.
- G. Remove the check valve balls and spring.
- H. Remove the release valve.

II. Clean and inspect

- A. Use the solvent to clean all of the removed parts and housing internal surfaces.
- B. Inspect all surfaces for damage.

- C. Inspect seals for nicks and cuts.
- D. Replace seals.

III. Reassemble and test

- A. Install the release valve.
- B. Install the check valve balls and spring.
- C. Make sure balls are properly seated and operate properly.
- D. Install pumping piston with seal.
- E. Install the ram with seal.
- F. Install the retaining ring.
- F. Fill with clean filtered fluid.

(NOTE: It may be necessary to bleed air from the jack.)

- G. Test the operation of the jack.

LESSON PLAN: 4

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT 1 : ORIENTATION TO FLUID POWER/HYDRAULICS

DEMONSTRATION: I-4

INTERACTION ITEMS: (Review Items)

1. Note the location of the check valve balls. All the balls and springs are not the same size. Will the jack work properly if they are mixed up?
2. Remove old seals with proper tools to prevent damage to what surfaces?

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

1. Review operation of the hydraulic jack, using TM 1 (Operation of a Hydraulic Jack).
2. Draw a block diagram of the hydraulic system used in the hydraulic jack.

LESSON PLAN: 4

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT I : ORIENTATION TO FLUID POWER/HYDRAULICS

DEMONSTRATION: 1-4

EVALUATION ITEMS:

The student has satisfactorily completed the following steps of procedure:

- I. Disassemble.
- II. Clean and inspect.
- III. Reassemble and test.

Yes ____ No ____

Instructor's Signature
(Verifying Satisfactory Completion)

(Date)

LESSON PLAN: 1

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

INFORMATION TOPIC: II-1

RESERVOIRS
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Define reservoir.
2. Name two types of reservoirs.
3. - Select reasons for using a pressurized reservoir.
4. Select functions of a reservoir.
5. Identify the parts of a properly designed, vented reservoir.
6. Identify the parts of a properly designed, pressurized reservoir.
7. Draw the symbol for a vented and pressurized reservoir.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Parts of a Properly Designed, Vented Reservoir
2. TM 2: Parts of a Properly Designed, Pressurized Reservoir

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service. Moline, IL: Deere and Company, 1979. Chapter 8.

REFERENCES: (Instructor's Additional Information)

Fluid Power I. Cleveland, OH: Parker-Hannifan Corporation, 1979.

Fundamentals of Service. Moline, IL: Deere and Company, 1979.

Industrial Hydraulics Manual. Troy, MI: Sperry Rand Corporation, 1970.

INTRODUCTION:

All components of a hydraulic system have interrelated effects; contamination, air, and excessive heat can result from various component failures. One such component is the reservoir. Some types require special services which every service worker must know.

LESSON PLAN: 1

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-1

OUTLINE: (Key Points)

- I. Reservoir - container for holding a supply of fluid
- II. Types of reservoirs
 - A. Vented to atmosphere
 - B. Pressurized and sealed
- III. Reasons for using a pressurized reservoir
 - A. Contamination is reduced
 - B. Condensation is reduced
 - C. Helps to force fluid to the pump to prevent cavitation of the pump
- IV. Functions of a reservoir
 - A. Provides fluid to replace system leakage
 - B. Contains excess fluid resulting from system volume changes
(NOTE: System volume changes occur when a cylinder is retracted or extended.)
 - C. Helps to cool system
 - D. Helps to separate dirt and air from fluid
- V. Parts of a properly designed, vented reservoir (TM 1)
 - A. Filler breather cap and strainer basket
 - B. Fluid level gauge and temperature gauge
 - C. Baffle
(NOTE: The baffle is optional. It helps to separate inlet fluid from the outlet fluid. It also assists in air and dirt separation and cooling.)

D. Reservoir outlet

(NOTE: The reservoir outlet goes to the pump.)

E. Return lines

F. Intake filter screen

(NOTE: The intake filter screen protects the pump.)

G. Drain plug

(NOTE: Some drain plugs are magnetic to help remove metal chips in fluid.)

H. Inspection plate

(NOTE: Used to gain entrance for purpose of cleaning)

VI. Parts of a properly designed pressurized reservoir (TM 2)

A. Filler cap

B. Fluid level gauge

C. Baffle

D. Reservoir outlet

E. Return lines

F. Intake filter screen

G. Drain plug

H. Inspection plate

I. Pressure regulator

J. Air line

K. Relief valve

(NOTE: Reservoir construction for a pressurized reservoir is of a special design; different from vented design.)

VII. Symbols for reservoirs

A. Vented

B. Pressurized

LESSON PLAN: 1

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-1

INTERACTION ITEMS: (Review Items)

1. Explain why the statement "A pump sucks fuel from a reservoir" is false.
2. What conditions would prevent a system from cooling?
3. Can both cleaning and inspection be performed through the inspection plate?

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

Let students locate as many reservoirs as possible in the shop or designated area.

LESSON PLAN: 1

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

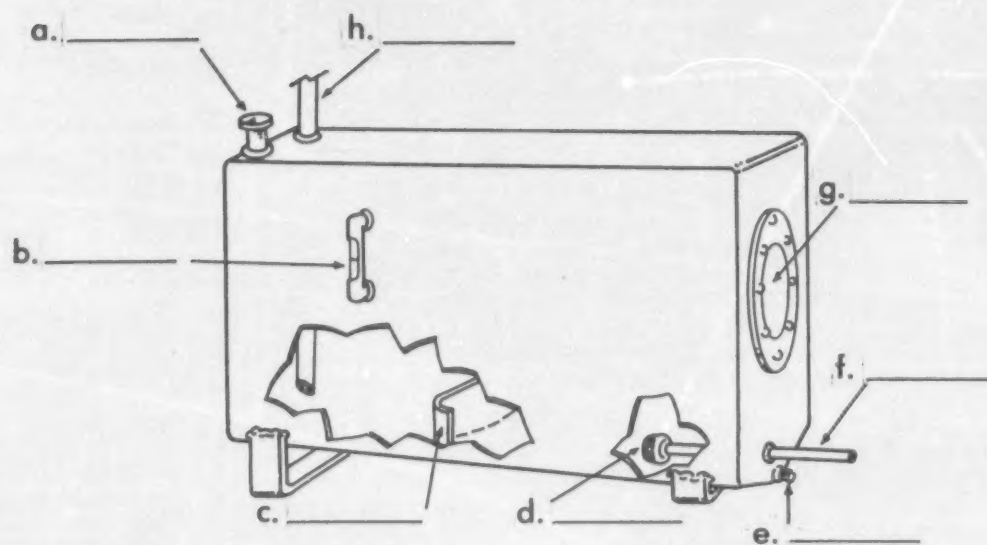
UNIT II : COMPONENTS

INFORMATION TOPIC: II-1

EVALUATION ITEMS:

1. Define reservoir.
2. Name two types of reservoirs.
 - a.
 - b.
3. Select reasons for using a pressurized reservoir by placing an "X" in the appropriate blanks.
 - ☐ a. Increases condensation
 - ☐ b. Reduces contamination
 - ☐ c. Helps to force the fluid to the baffle
 - ☐ d. Reduces condensation
 - ☐ e. Helps to force fluid to the pump to prevent cavitation of the pump
4. Select functions of a reservoir by placing an "X" in the appropriate blanks.
 - ☐ a. Helps to cool system
 - ☐ b. Contains excess fluid resulting from system volume changes
 - ☐ c. Connects main components of system
 - ☐ d. Helps to separate dirt and air from fluid
 - ☐ e. Provides mechanical action for movement of fluid
 - ☐ f. Provides fluid to replace system leakage

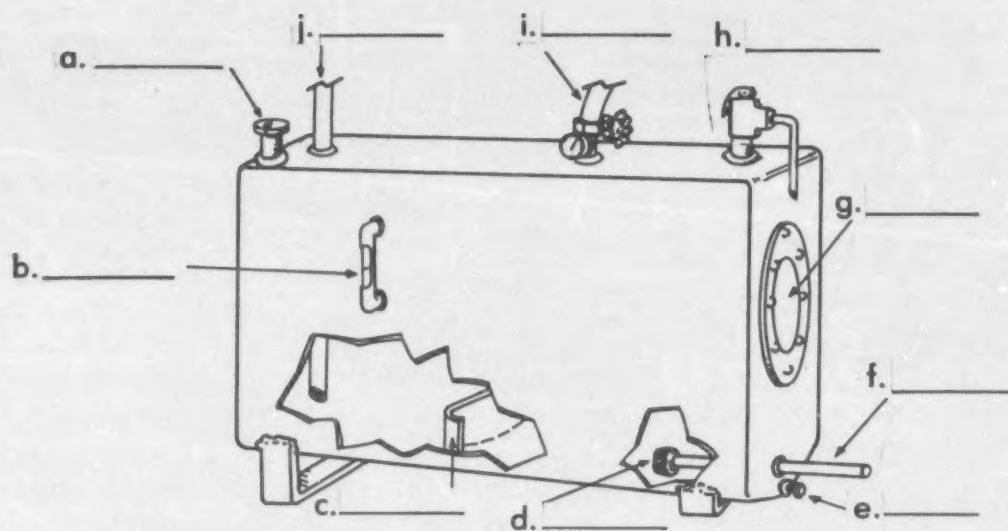
5. Identify the parts of a properly designed, vented reservoir.



a. _____
 b. _____
 c. _____
 d. _____

e. _____
 f. _____
 g. _____
 h. _____

6. Identify the parts of a properly designed, pressurized reservoir.



a. _____
 b. _____
 c. _____
 d. _____
 e. _____

f. _____
 g. _____
 h. _____
 i. _____
 j. _____

7. Draw the symbol for reservoirs.

a. Vented

b. Pressurized

LESSON PLAN: 1

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

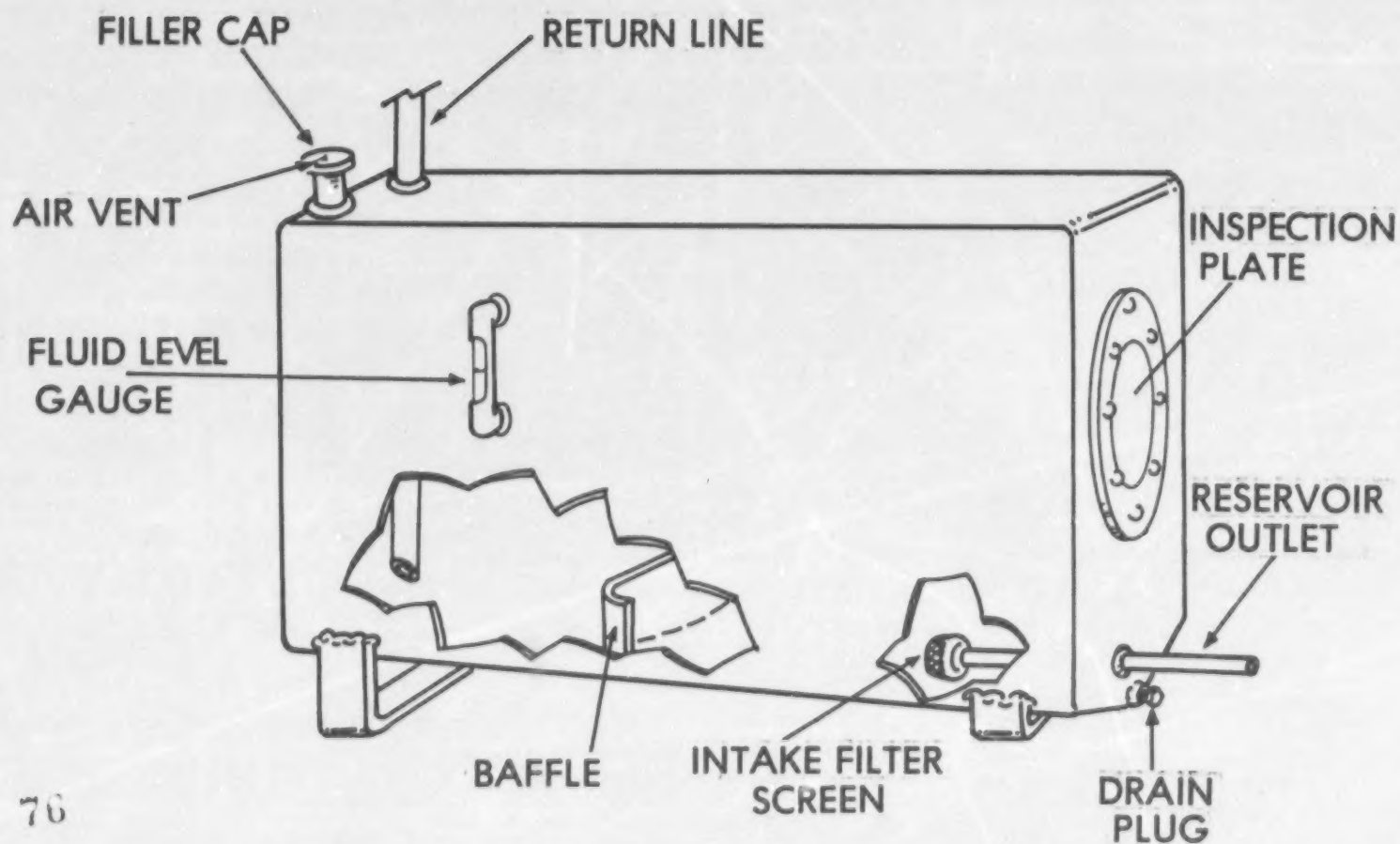
UNIT II : COMPONENTS

INFORMATION TOPIC: II-1

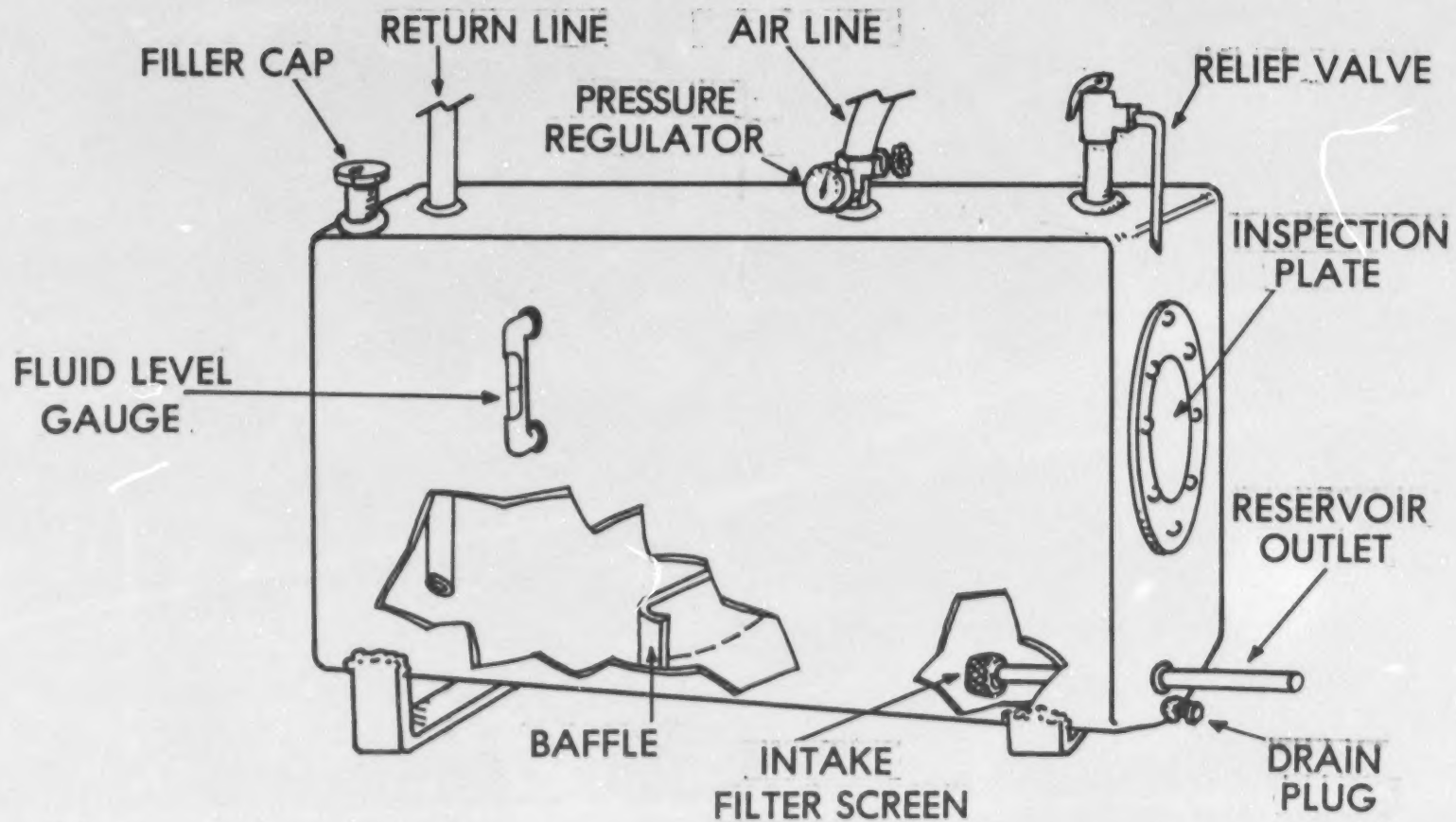
ANSWERS TO EVALUATION ITEMS:

1. Container for holding a supply of fluid
2.
 - a. Vented to atmosphere
 - b. Pressurized and sealed
3. b, d, and e
4. a, b, d, and f
5.
 - a. Filler cap
 - b. Fluid level gauge
 - c. Baffle
 - d. Intake filter screen
 - e. Drain plug
 - f. Reservoir outlet
 - g. Inspection plate
 - h. Return line
6.
 - a. Filler cap
 - b. Fluid level gauge
 - c. Baffle
 - d. Intake filter screen
 - e. Drain plug
 - f. Reservoir outlet
 - g. Inspection plate
 - h. Pressure regulator
 - i. Air line
7.
 - a.
 - b.

Parts of a Properly Designed , Vented Reservoir



Parts of a Properly Designed , Pressurized Reservoir



LESSON PLAN: 2

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

DEMONSTRATION LESSON: II-2

CLEAN AND INSPECT VENTED RESERVOIR
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Clean a vented reservoir.
2. Inspect a vented reservoir.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. One mobile application reservoir for every three students.

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service. Moline, IL: Deere and Company, 1979. Chapter 8.

REFERENCES: (Instructor's Additional Information)

Fluid Power I. Cleveland, OH: Parker-Hannifan Corporation, 1979.

Fundamentals of Service. Moline, IL: Deere and Company, 1979.

Industrial Hydraulics Manual. Troy, MI: Sperry Rand Corporation, 1970.

INTRODUCTION:

In order for a reservoir to work properly, it must be maintained correctly. Proper cleaning and inspections are excellent forms of preventive maintenance, insuring trouble-free operation of the hydraulic system.

LESSON PLAN: 2

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-2

TOOLS, EQUIPMENT, AND MATERIALS:

Wrenches (as required)
Screwdrivers (as required)
Vented reservoir
Lint-free shop towel or squeegees

STEPS OF PROCEDURE: (Job Sheet)

I. Clean.

- A. Drain fluid.
- B. Remove inspection plate.
- C. Remove sludge on bottom of reservoir with lint-free cloth wetted with solvent.
- D. Clean air vent.
(NOTE: Inspect and test relief valve on pressurized reservoir.)
- E. Clean intake filter screen with solvent.
- F. Flush inside of reservoir with solvent.

II. Inspect.

(NOTE: After completing each point in the inspection, check the appropriate box and briefly describe the condition of the components.)

- A. Examine reservoir for leaks, cracks, and broken welds.
- B. Inspect inlet filter screen; replace if damaged.
- C. Inspect filler cap to insure proper operation.
- D. Check air vent to insure that it is not plugged.
- E. Check operation of relief valve.

III. Have instructor check work.

IV. Refill with clean filtered oil.

LESSON PLAN: 2

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-2

INTERACTION ITEMS: (Review Items)

1. What is the purpose of the air vent? (Allows atmospheric pressure to pressurize tank to 14.7 psi)
2. Why not use gasoline as a cleaner? (Explosive fumes during and after cleaning are extremely hazardous.)

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES

LESSON PLAN: 2

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-2

EVALUATION ITEMS:

The student has satisfactorily completed the following steps of procedure:

- I. Cleaned a vented reservoir.
- II. Inspected a vented reservoir.
- III. Fill with clean filtered oil and inspect filler cap.

Yes No

Instructor's Signature
(Verifying Satisfactory Completion)

Date

LESSON PLAN: 3

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

INFORMATION TOPIC: II-3

LINES, FITTINGS, AND COUPLERS
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Match terms related to lines, fittings, and couplers with the correct definitions.
2. Select true statements concerning the characteristics of steel pipe.
3. List the types, construction, and size of steel tubing.
4. Select true statements concerning the characteristics of hydraulic hose.
5. Identify types of fittings commonly used with tubing.
6. Identify types of hose ends used in hydraulic systems.
7. Identify types of fittings used in hydraulic systems.
8. Select factors to consider when routing tubing in hydraulic systems.
9. List conditions to avoid when routing hydraulic hose.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Sizing of Steel Pipe
2. TM 2: Working Pressure for Steel Pipe
3. TM 3: Hose Construction and Hose Types
4. TM 4: Types of Fittings Commonly Used with Tubing
5. TM 5: Types of Hose Ends
6. TM 6: Types of Fittings Used in Hydraulic Systems
7. TM 7: Routing Hydraulic Hose and Tubing

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Co., 1979, Chapter 8.

REFERENCES: (Instructor's Additional Information)

Fluid Power I. Cleveland, OH: Parker-Hannifin Corporation, 1979.

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979.

Industrial Hydraulics Manual. Troy, MI: Sperry Rand Corporation, 1970.

INTRODUCTION:

There is a need to learn about how the hydraulic fluid flows from one place to another. Pressures, flow rates, and temperature are important factors that cannot be overlooked.

LESSON PLAN: 3

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-3

OUTLINE: (Key Points)

I. Terms and definitions

- A. **Pipe** - rigid fluid conductor which is not intended to be bent or shaped
- B. **Tubing** - a semi-rigid fluid conductor which is customarily bent into a desired shape
- C. **Hose** - flexible fluid conductor which can readily bend with movement of machine members
- D. **Hose end** - a fitting which is attached onto a hose to allow the hose to be connected to other components

(NOTE: Swivel and rigid design)

- E. **Fitting** - a device for connecting hydraulic components, such as a hose to a valve
- F. **Joint Industrial Council** - an organization which is responsible for promotion of industrial standards

(NOTE: JIC is the abbreviation for the Joint Industrial Council.)

- G. **Skive** - to remove the outer covering on a hose

II. Characteristics of steel pipe

(NOTE: Do not use galvanized pipe in hydraulic systems.)

A. Size (TM 1)

- 1. Size is typically specified by nominal inside diameter.
- 2. Wall thickness (for a given size) is described by a schedule number.

B. Pressure range (TM 2)

- 1. Schedule 40 is commonly used for low pressure lines.

2. Schedule 80 is commonly used for high pressure lines.
3. Schedule 160 is commonly used for very high pressure lines.

III. Characteristics of annealed steel tubing

A. Types

1. Carbon steel
2. Stainless

B. Construction

1. Seamless
2. Welded

C. Size (Table 1)

TUBE OD	WALL THICKNESS	TUBE ID
1/8	0.028	0.069
	.032	.061
	.035	.055
3/16	0.032	0.1235
	.035	.1175

Table 1

1. Indicated by (actual) outside diameter and wall thickness
2. Wall thickness sometimes described as:
 - a. Thin wall (low pressure)
 - b. Standard (high pressure)
 - c. Thick wall (very high pressure)

IV. Characteristics of hydraulic hose

A. Construction (TM 3)

1. Inner tube - selected for compatibility to fluid use

2. Reinforcement - selected for pressure service requirements

3. Cover - selected on environmental conditions

(NOTE: The reinforcement typically consists of one or more layers of steel and/or fabric braid.)

B. Size

1. Factors to specify

- a. Inside diameter
- b. Working pressure
- c. Construction
- d. Bend radius requirements
- e. Fatigue resistance

2. Standard hose types (TM 3)

- a. Standard developed by Society of Automotive Engineers (SAE).
- b. Hoses are guaranteed by the manufacturer to meet a minimum safety standard.

V. Types of fittings commonly used with tubing (TM 4)

A. Flare (JIC 37° flare or 45° flare)

(NOTE: The end of the tubing is flared to mate with a fitting. 37° is most common and 45° is used in some low pressure applications.)

B. Flareless

1. Swage type

(NOTE: The tubing material is compressed to form a build-up of tubing material around a retaining ring. This ring is used to hold the fitting on the tubing.)

2. Bite type

(NOTE: A retaining ring is compressed onto the tube. The ring "bites" into the tubing. The primary difference between these two types of fittings is that the swage type displaces the tubing to conform around the retaining ring. The bite type cuts or bites into the tubing.)

C. Braze-on

(NOTE: The fitting is brazed or welded onto the end of the tubing.)

VI. Types of hose ends used in hydraulic systems (TM 5)

A. Permanent: swivel, rigid

(NOTE: The fitting is crimped or swaged onto the hose.)

B. Reusable: swivel, rigid

1. Nonskive

(NOTE: The hose cover is not removed. The hose end nipple is inserted into the hose. A socket (sleeve) is screwed or pushed onto the hose end to clamp it to the hose.)

2. Skive

(NOTE: The hose cover is removed (skived) prior to the installation of the hose end. The installation is the same as the nonskive.)

3. Clamp-on

(NOTE: A barbed hose end nipple is inserted into hose and a clamp is bolted onto the hose to provide grip.)

VII. Types of fittings used in hydraulic systems (TM 6)

A. Pipe thread - National Pipe Thread (NPT), National Pipe Thread Dry Seal (NPTF)

B. Straight thread

(NOTE: Straight thread should be used with an O-ring.)

C. Flare, self-flare

D. Split flange

VIII. Factors to consider when routing tubing in hydraulic systems

A. Avoid straight-line hook-ups.

(NOTE: These do not allow expansion and contraction.)

B. Use the fewest and simplest bends possible.

- C. Support long runs of tubing; use resilient shock absorbent clamps.
- D. Avoid interference with operator controls.

IX. Conditions to avoid when routing hydraulic hose (TM 7)

- A. Taut hose
- B. Loops
- C. Twists
- D. Rubbing
- E. Heat sources
- F. Sharp bends

LESSON PLAN: 3

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-3

INTERACTION ITEMS: (Review Items)

1. Galvanized pipe flakes off and will leave metal deposits on components and promotes early failures (seed failure).
2. Caution should be used when installing reusable hose ends so that the inner tube is not peeled back causing a restriction in one direction.
3. Why can't copper tubing be used?

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

1. Use small pieces of pipe and measure wall thickness and inside diameter to verify schedule number.
(NOTE: Do not use galvanized pipe in hydraulic systems.)
2. Use small pieces of steel tubing for seamless and welded construction identification.
3. Identify JIC flare seal, pipe thread, and straight thread fittings.
4. Identify permanent and reusable hose ends.

LESSON PLAN: 3

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-3

EVALUATION ITEMS:

1. Match the terms on the right with the correct definitions.

- | | | | |
|-----------------------------|---|----|--------------------------|
| ☐ a. | Rigid fluid conductor which is not intended to be bent or shaped | 1. | Fittings |
| ☐ b. | A semi-rigid fluid conductor which is customarily bent into a desired shape | 2. | Pipe |
| ☐ c. | Flexible fluid conductor which can readily bend with movement of machine members | 3. | Skive |
| ☐ d. | A fitting which is attached onto a hose to allow the hose to be connected to other components | 4. | Hose |
| ☐ e. | A device for connecting hydraulic components, such as a hose to a valve | 5. | Joint Industrial Council |
| ☐ f. | An organization which is responsible for promotion of industrial standards | 6. | Tubing |
| ☐ g. | To remove the outer covering on a hose | 7. | Hose end |

2. Select true statements concerning the characteristics of steel pipe by placing an "X" in the appropriate blanks.

- ☐ a. Size is typically specified by outside diameter.
- ☐ b. Wall thickness is described by a schedule number.
- ☐ c. Schedule 40 is commonly used for low pressure lines.
- ☐ d. Schedule 160 is commonly used for very high pressure lines.
- ☐ e. Schedule 80 is commonly used for low pressure lines.

3. List the types, construction, and size of steel tubing.

a. Types

1.

2.

b. Construction

1.

2.

c. Size

1.

2.

a.

b.

c.

4. Select true statements concerning the characteristics of hydraulic hose by placing an "X" in the appropriate blanks.

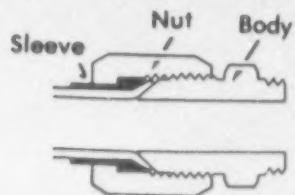
___ a. The construction of hydraulic hose consists of an inner tube, reinforcement, and cover.

___ b. Factors to specify size include outside diameter, working pressure, and construction.

___ c. Standard hose types were developed by the Society of Automotive Engineers (SAE).

___ d. Hoses are guaranteed by the manufacturer to meet a minimum safety standard.

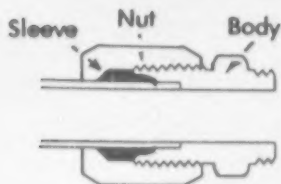
5. Identify the types of fittings commonly used with tubings.



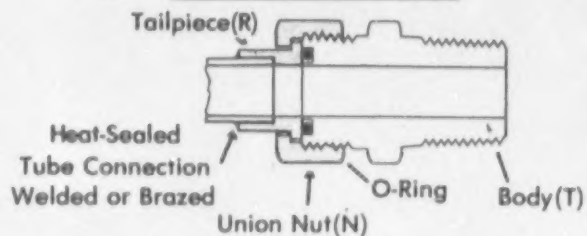
a. _____



b. _____

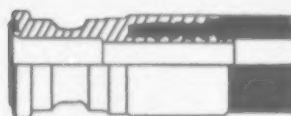


c. _____

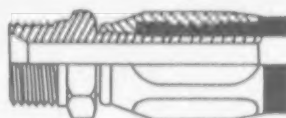


d. _____

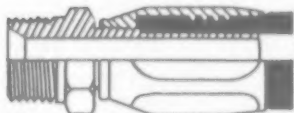
6. Identify types of hose ends used in hydraulic systems.



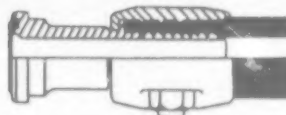
a. _____



b. _____



c. _____



d. _____

7. Identify types of fittings used in hydraulic systems.



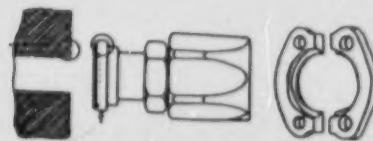
a. _____



b. _____



c. _____



d. _____

8. Select factors to consider when routing tubing in hydraulic systems by placing an "X" in the appropriate blanks.

- ___ a. All hook-ups should be straight-line.
- ___ b. Use as many bends as possible.
- ___ c. Support long runs of tubing.
- ___ d. Avoid interference with operator controls.

9. List five conditions to avoid when routing hydraulic hose.

a.

b.

c.

d.

e.

LESSON PLAN: 3

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-3

ANSWERS TO EVALUATION ITEMS:

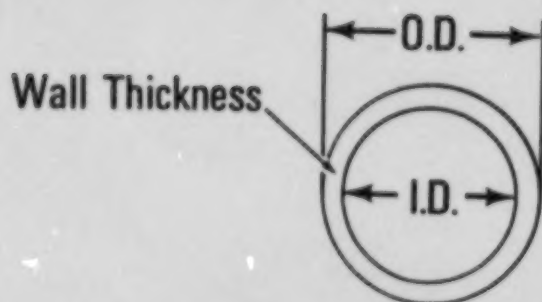
1.

a.	2	e.	1
b.	6	f.	5
c.	4	g.	3
d.	7		
2. b, c, d
3. Discussion should include:
 - a. Type
 - 1) Carbon
 - 2) Stainless
 - b. Construction
 - 1) Seamless
 - 2) Welded
 - c. Size
 - 1) Indicated by outside diameter and wall thickness
 - 2) Wall thickness sometimes described as:
 - a) Thin wall
 - b) Standard
 - c) Thick wall
4. a, c, d
5.
 - a. Flare, self-flare
 - b. Swage type flareless
 - c. Bite type flareless
 - d. Braze-on
6.
 - a. Permanent
 - b. Nonskive reusable
 - c. Skive reusable
 - d. Clamp-on reusable
7.
 - a. Pipe thread
 - b. Flare
 - c. Straight thread
 - d. Split flange
8. c, d

9. Any five of the following:

- a. Taut hose
- b. Loops
- c. Twists
- d. Rubbing
- e. Heat
- f. Sharp bends

Sizing of Steel Pipe



Schedule 40 Schedule 80 Schedule 160

Nominal Size	Pipe O.D.	INSIDE DIAMETER		
		Schedule 40	Schedule 80	Schedule 160
1/8	.405	.269	.215	
1/4	.540	.364	.302	
3/8	.675	.493	.423	
1/2	.840	.622	.564	.466
3/4	1.050	.824	.742	.587
1	1.315	1.049	.957	.815
1 1/4	1.660	1.380	1.278	1.160
1 1/2	1.900	1.610	1.500	1.338
2	2.375	2.067	1.939	1.689
2 1/2	2.875	2.469	2.323	2.125
3	3.500	3.068	2.900	2.624

Working Pressure for Steel Pipe

Based on ASTM A53 Grade B or
A106 Grade B Seamless Pipe.

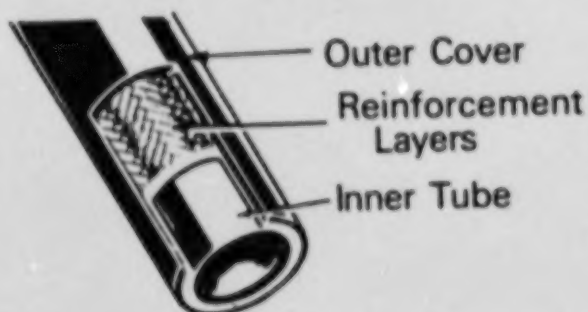
Working Pressure (PSI)
(Burst Pressure)

(Approximate Values Only)

Nominal Size	Schedule 40	Schedule 80	Schedule 160
$\frac{1}{8}$	3500 (20,200)	4800 (28,000)	—
$\frac{1}{4}$	2100 (19,500)	4350 (26,400)	—
$\frac{3}{8}$	1700 (16,200)	3800 (22,500)	—
$\frac{1}{2}$	2300 (15,600)	4100 (21,000)	7300 (26,700)
$\frac{3}{4}$	2000 (12,900)	3500 (17,600)	8500 (25,000)
1	2100 (12,100)	3500 (15,900)	5700 (22,300)
$1\frac{1}{4}$	1800 (10,100)	3000 (13,900)	4400 (18,100)
$1\frac{1}{2}$	1700 (9,100)	2800 (12,600)	4500 (17,700)
2	1500 (7,800)	2500 (11,000)	4600 (17,500)

Hose Construction and Hose Types

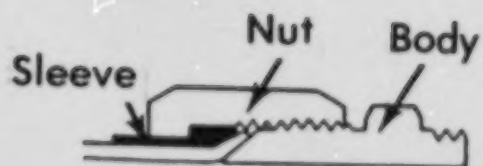
SAE Number	Inner Tube	Reinforcement	Cover
SAE 100R1	Synthetic Rubber	1 High Tensile Steel	Synthetic Rubber
SAE 100R2	Synthetic Rubber	2 Wire Braids 2 Spiral Plies and 1 Wire Braid	Synthetic Rubber
SAE 100R3	Synthetic Rubber	2 Textile Braids	Synthetic
SAE 100R4	Synthetic Rubber	Braided Textile Fibers/ Spiral Body Wire	Synthetic
SAE 100R5	Synthetic Rubber	1 Textile Braid a High Tensile Steel Wire Braid	Cotton Braid
SAE 100R6	Synthetic Rubber	1 Textile Braid	Synthetic Rubber
SAE 100R7	Thermoplastic	Synthetic Fiber	Thermoplastic
SAE 100R8	Thermoplastic	Synthetic Fiber	Thermoplastic
SAE 100R9	Synthetic Rubber	4 Spiral Plies Wrapped In Alternating Directions	Synthetic Rubber
SAE 100R10	Synthetic Rubber	4 Spiral Plies of Heavy Wire Wrapped in Alternating Directions	
SAE 100R11	Synthetic Rubber	6 Spiral Plies of Heavy Wire Wrapped in Alternating Directions	Synthetic Rubber



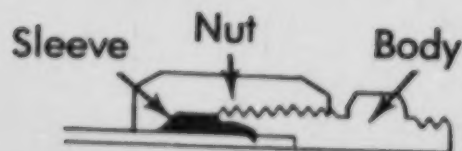
Flexible Hose Construction

SAE Hose Types

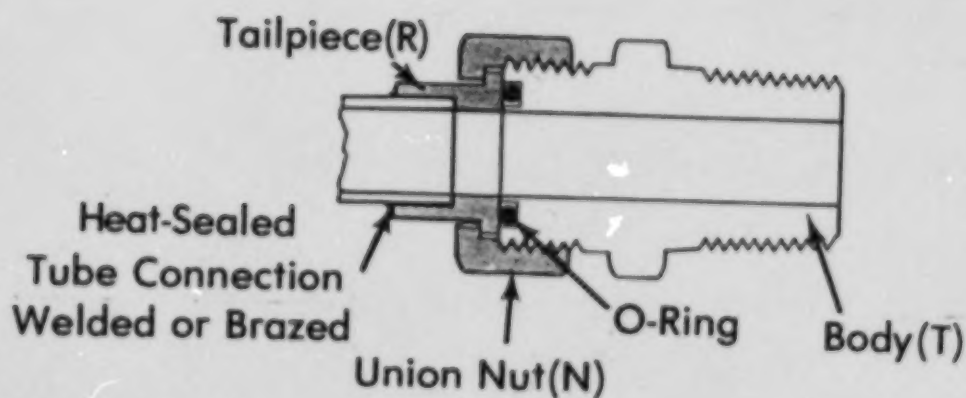
Types of Fittings Commonly Used with Tubing



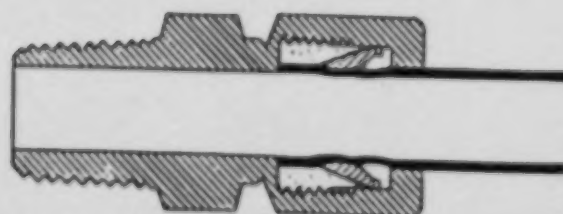
Flared



Bite Type Flareless

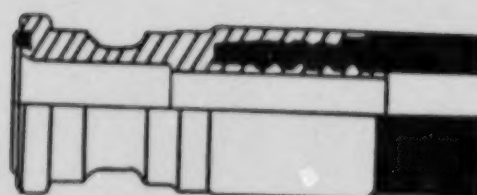


Braze-on

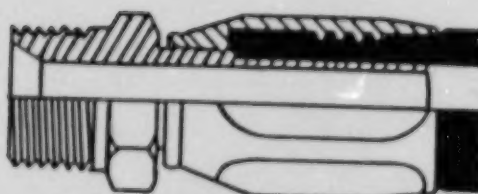


Swage Type Flareless

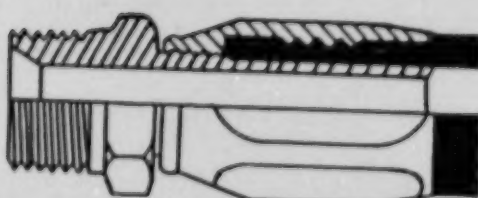
Types of Hose Ends



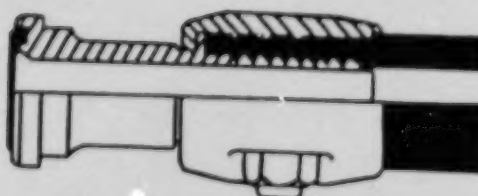
Permanent
Hose Fitting



Skive Fitting



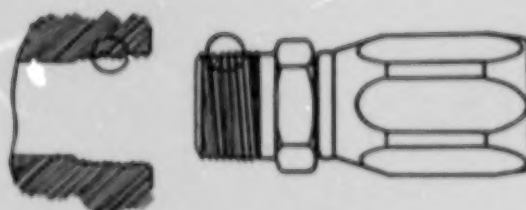
No-Skive Fitting



Clamp Type Fitting

Types of Fittings Used in Hydraulic Systems

1. Pipe Thread
(Tapered)



2. Dry Seal To
30° Cone Seat
(Inverted Flare)



3. Flare Seal
To Cone Seat



J.I.C. Flare Seal
to 37° Cone seat



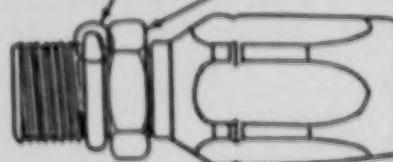
S.A.E. Flare Seal
To 45° Cone Seat



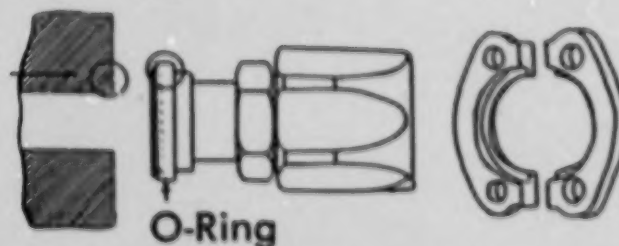
4. Straight Thread
with O-Ring
Seal



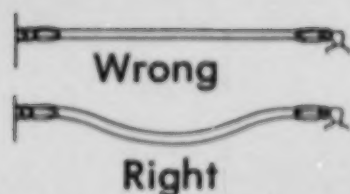
O-Ring Lock Nut



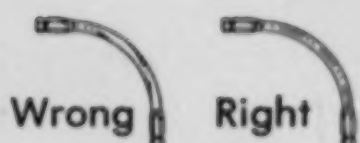
5. Split Flange
O-Ring Seal



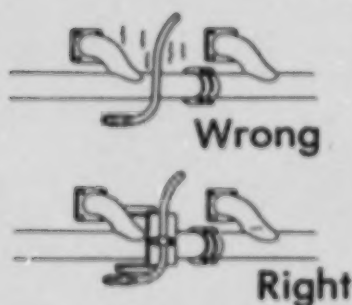
Routing Hydraulic Hose and Tubing



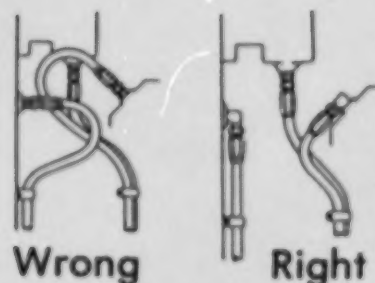
1. Avoid Taut Hose



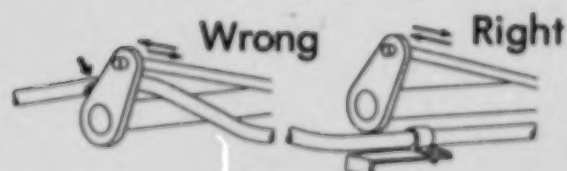
3. Avoid Twisting



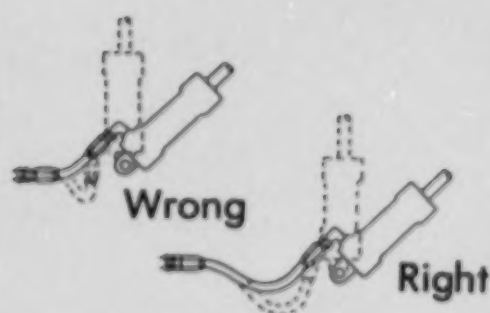
5. Avoid Heat



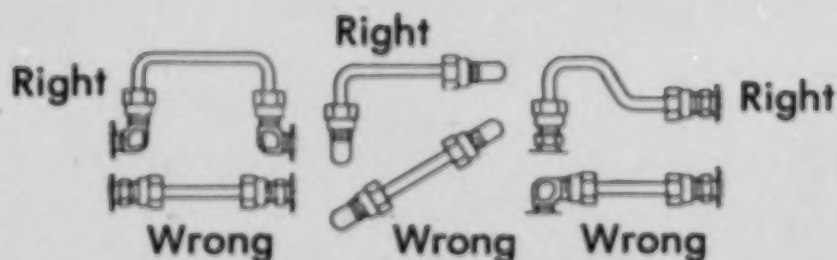
2. Avoid Loops



4. Avoid Rubbing



6. Avoid Sharp Bends



LESSON PLAN: 4

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

DEMONSTRATION LESSON: II-4

REPLACE A REUSABLE HOSE END
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Remove the hose ends from old hose.
2. Measure replacement hose and cut to length.
3. Install old hose ends on new section of replacement hose.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

LESSON PLAN: 4

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : C COMPONENTS

DEMONSTRATION: II-4

TOOLS, EQUIPMENT, AND MATERIALS

Wrenches (as required)

Hose with reusable hose ends

Replacement hose

(NOTE: Replacement hose must be matched to the hose ends.)

Tape measure

Tool to cut hose

Vise

Knife

STEPS OF PROCEDURE: (Job Sheet)

- I. Remove the hose ends from the old hose.

(NOTE: For clamp on hose ends the screw should be removed and the two halves of the clamp are to be removed. The hose end nipple can then be removed. For skive and nonskive hose ends the socket (sleeve) should be pulled off or unscrewed as appropriate. The hose end nipple can then be removed.)

- II. Measure replacement hose and cut to length.
- III. If the hose end is a skive type, use the knife to remove the outer covering where the sleeve is to be placed on the hose.
- IV. Lubricate the end of the hose and place the sleeve on the hose.
- V. Place the sleeve and hose assembly into the vise.
- VI. Insert the nipple and screw it into the sleeve and hose assembly until the nipple seats against the sleeve.
- VII. Repeat for the other end.

LESSON PLAN: 4

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-4

INTERACTION ITEMS: (Review Items)

1. Make sure inner tube is not peeled back causing a restriction (one way).

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES

LESSON PLAN: 4

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-4

EVALUATION ITEMS:

The student has satisfactorily completed the following steps of procedure:

- I. Removed hose ends from old hose.
- II. Measured and cut new hose material to proper length.
- III. Installed old hose ends on new section of replacement hose.

Yes ____ No ____

Instructor's Signature
(Verifying Satisfactory Completion)

Date

LESSON PLAN: 5

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

INFORMATION TOPIC: II-5

SEALS
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Match terms and definitions associated with seals.
2. Describe two types of leakage paths in hydraulic systems.
3. Identify types of sealing devices used in hydraulic systems.
4. Match types of seals with their applications.
5. Identify types of seal construction.
6. Select factors to consider concerning seal material.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Typical Leakage Paths
2. TM 2: Types of Sealing Devices
3. TM 3: Types of Seal Construction (T-Ring Seal)
4. TM 4: Types of Seal Construction (Cup-Type Seal)
5. TM 5: Types of Seal Construction (Piston Ring Seal)

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979, Chap. 9.

REFERENCES: (Instructor's Additional Information)

Fluid Power I. Cleveland, OH: Parker-Hannifin Corporation, 1979.

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979.

Industrial Hydraulics Manual. Troy, MI: Sperry Rand Corporation, 1970.

INTRODUCTION:

In hydraulic systems and components we have leakage paths that need to be blocked by use of seals. Seals appear to be simple objects when held in the hand. But in use they are complex, precision parts and must be treated carefully if they are to do their job properly. Seals hold the fluid under pressure in the system and keep dirt and grime out of the system.

LESSON PLAN: 5

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-5

OUTLINE: (Key Points)

I. Terms and definitions

- A. **Sealing device** - any device which keeps hydraulic fluid from flowing between certain passages or keeps foreign material from entering the system
- B. **Seal ring (seal)** - a type of seal whose basic shape is a ring; may use various complex shapes to improve sealing characteristics
- C. **O-ring** - a simple seal with a round cross section
- D. **Gasket** - a thin flat seal sandwiched between two metal surfaces
- E. **Packing** - a seal which resembles a spring
- F. **Counter-bore** - an enlarged area around a spool or shaft to allow room to accommodate a seal or O-ring
- G. **Back-up ring** - a ring installed behind an O-ring or seal to provide an improved sealing surface for the O-ring

II. Types of leakage paths in hydraulic systems (TM 1)

- A. **Internal** - leakage from one compartment to another within a component
- B. **External** - leakage from within the component to the outside

III. Types of sealing devices (TM 2)

- A. **Seal**
- B. **V-packing**
- C. **O-ring**
- D. **Back-up ring**
- E. **Gasket**

LESSON PLAN: 5

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-5

INTERACTION ITEMS: (Review Items)

1. Wrap tape in the opposite direction of threads so tape will remain in the threads and not be pushed out.
2. What type of seal is used between the piston and rod on TM 5?

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES

None

LESSON PLAN: 5

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-5

EVALUATION

1. Match the terms on the right with the correct definitions.

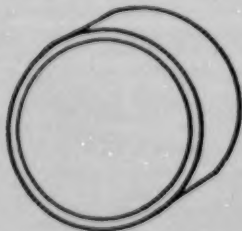
- | | | |
|--------|--|-------------------|
| ___ a. | Any device which keep hydraulic fluid from flowing between certain passages or keeps foreign material from entering the system | 1. Gasket |
| ___ b. | A type of seal whose basic shape is a ring; may use various complex shapes to improve sealing characteristics | 2. Packing |
| ___ c. | A simple seal with a round cross section | 3. Sealing device |
| ___ d. | A thin flat seal sandwiched between two metal surfaces | 4. O-ring |
| ___ e. | A seal which resembles a spring | 5. Seal ring |
| ___ f. | An enlarged area around a spool or shaft to allow room to accommodate a seal or O-ring | 6. Counter-bore |
| ___ g. | A ring installed behind an O-ring to provide an improved sealing surface for the O-ring | 7. Back-up ring |

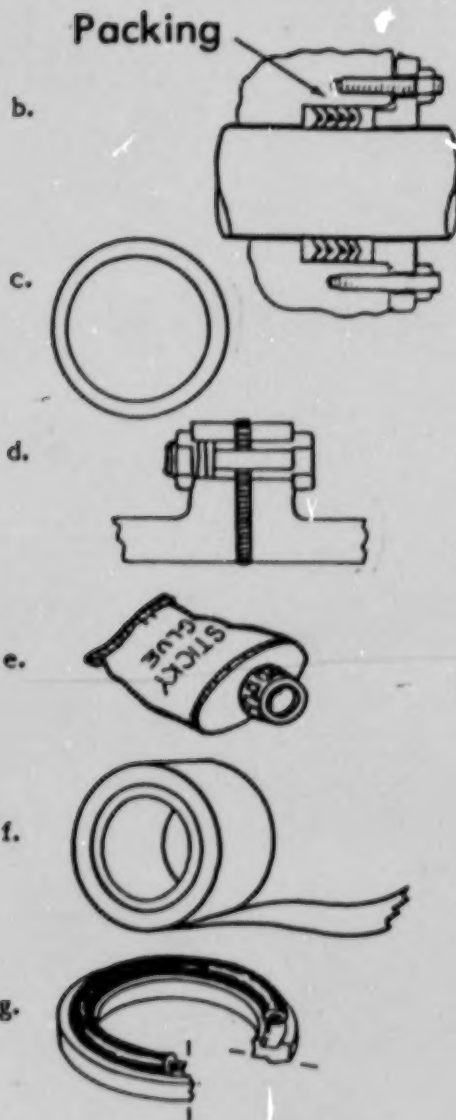
2. Describe two types of leakage paths in hydraulic systems.

- a. Internal
- b. External

3. Identify types of sealing devices used in hydraulic systems.

a.

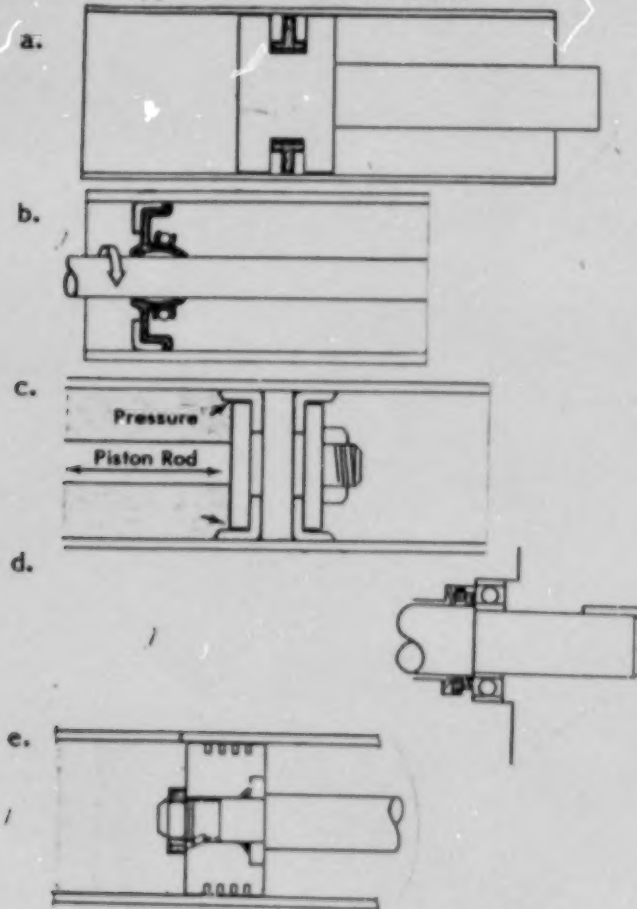




4. Match the types of seals on the right with their applications.

- | | | |
|--------|---|---------------|
| ___ a. | Used to prevent dirt from entering the system | 1. Static |
| ___ b. | Used where no mechanical movement occurs | 2. Wiper seal |
| ___ c. | Used where rotary or linear motion occurs | 3. Dynamic |

5. Identify types of seal construction.



6. Select factors to consider concerning seal material by placing an "X" in the appropriate blanks.

- ☐ a. Temperature extremes
- ☐ b. Wear characteristics
- ☐ c. Noise conditions
- ☐ d. Dynamic elasticity
- ☐ e. Compatability with the hydraulic fluid
- ☐ f. Exposure to environment
- ☐ g. Pressure of components

LESSON PLAN: 5

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

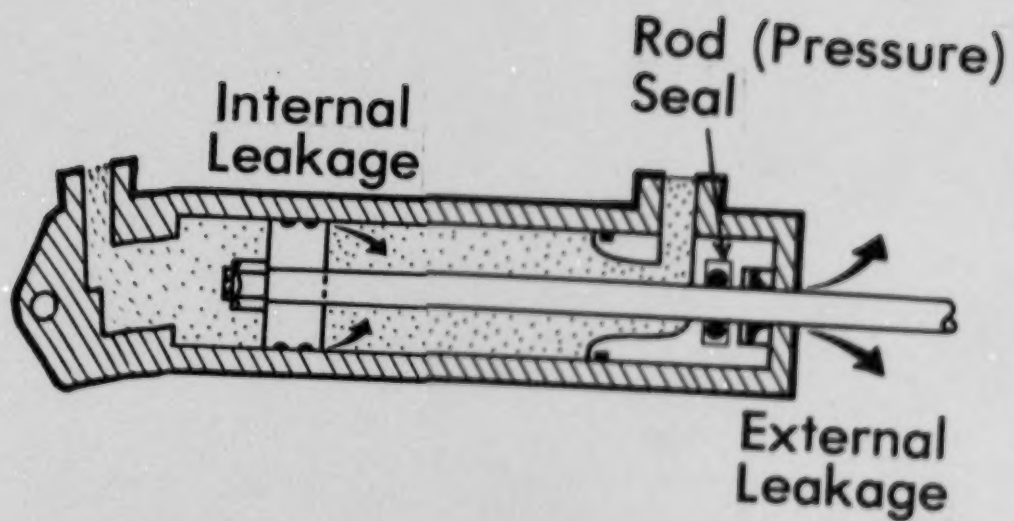
UNIT II : COMPONENTS

INFORMATION TOPIC: II-5

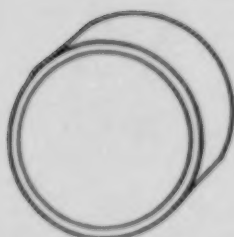
ANSWERS TO EVALUATION

1.
 - a. 3
 - b. 5
 - c. 4
 - d. 1
 - e. 2
 - f. 6
 - g. 7
2. Description should include:
 - a. Leakage from one compartment to another within a component
 - b. Leakage from within the component to the outside
3.
 - a. Seal
 - b. Packing
 - c. O-ring
 - d. Gasket
 - e. Liquid sealing compound
 - f. Plastic tape
 - g. Back-up ring
4.
 - a. 2
 - b. 1
 - c. 3
5.
 - a. T-ring
 - b. Lip seal
 - c. Cup seal
 - d. Face seal
 - e. Piston ring seal
6. a, b, e, f

Typical Leakage Paths



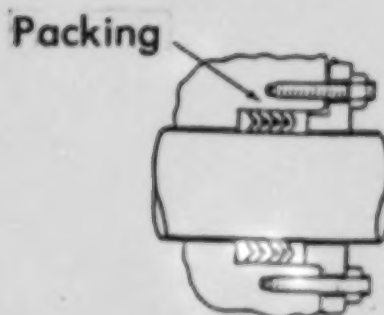
Types of Sealing Devices



Seal



O-Ring



Chevron or V-Shaped Packing

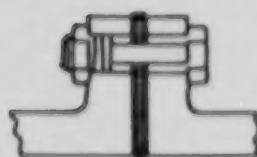
(Note: The lip is installed towards pressure.)

Back-up Ring with O-ring



(Note: Recessed area is installed towards O-Ring.)

Gasket



Sealing Compounds

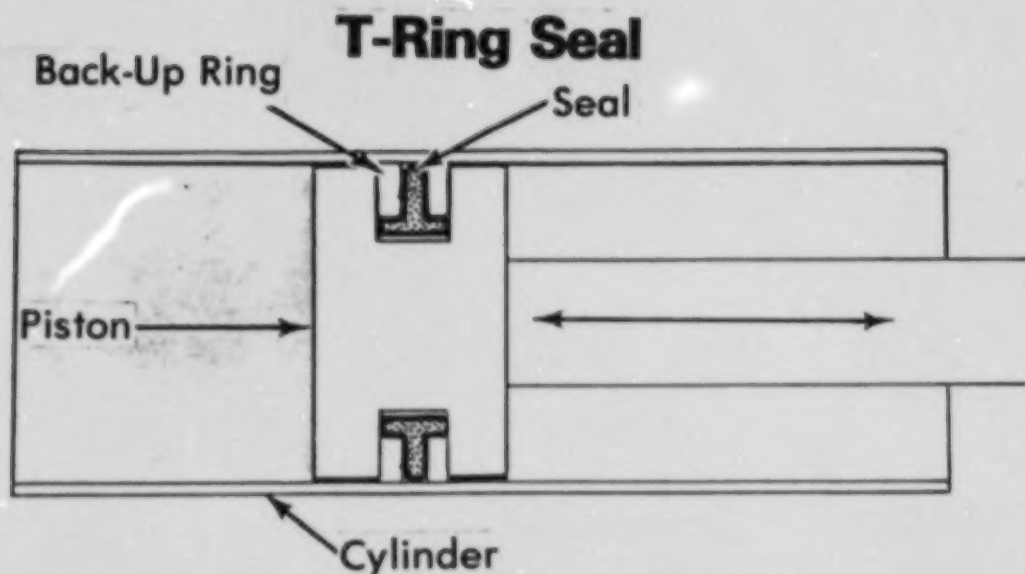


Glue



Plastic Tape

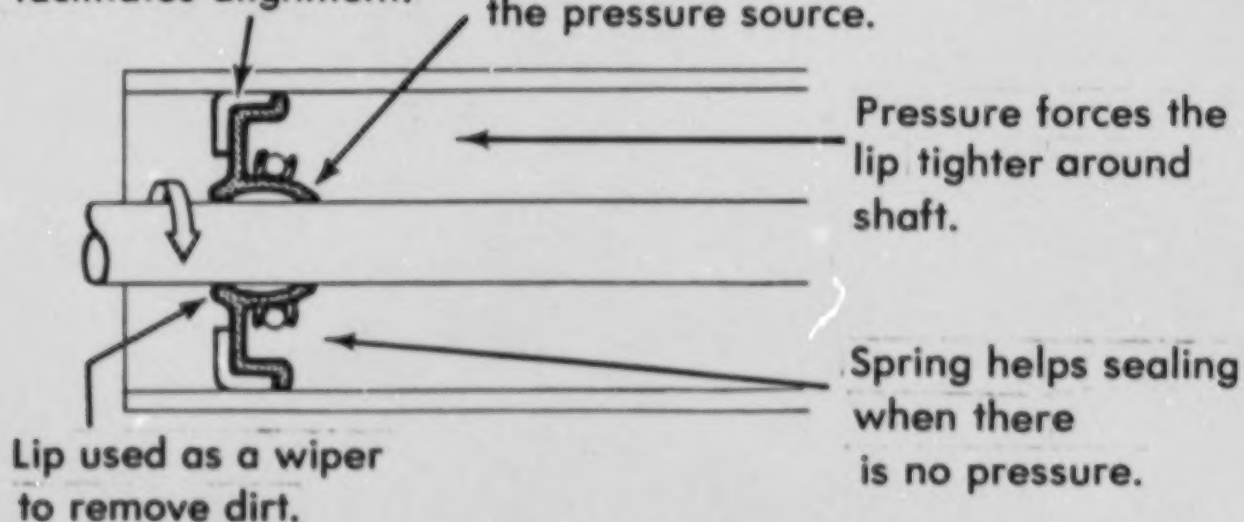
Types of Seal Construction



Double Lip Seal

Stamped housing gives seal rigidity, facilitates alignment.

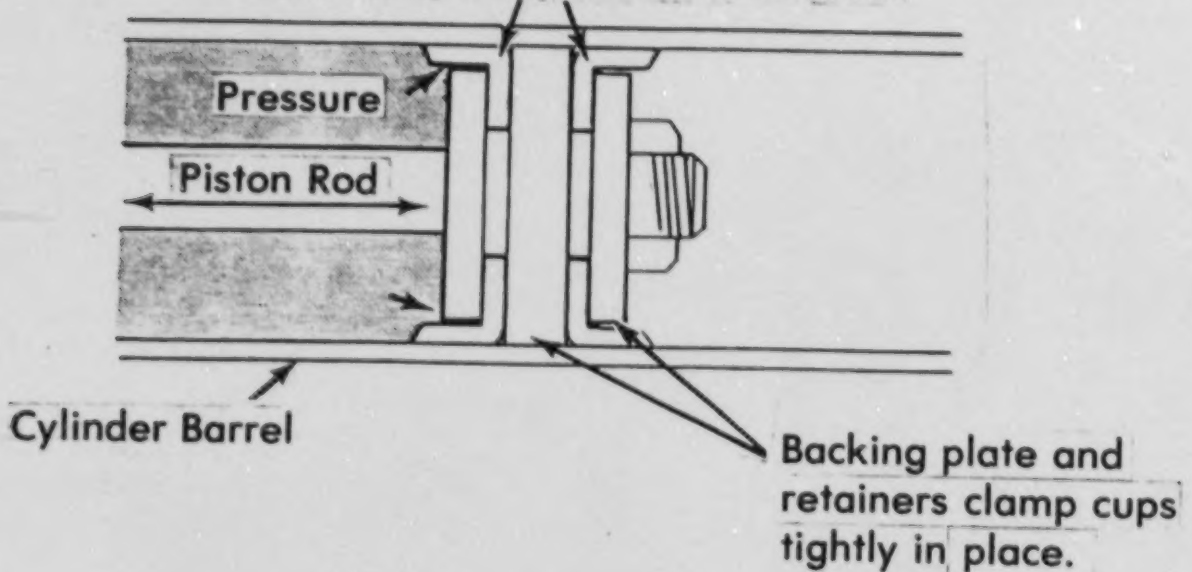
Lip (leather or synthetic) is installed toward the pressure source.



Types of Seal Construction

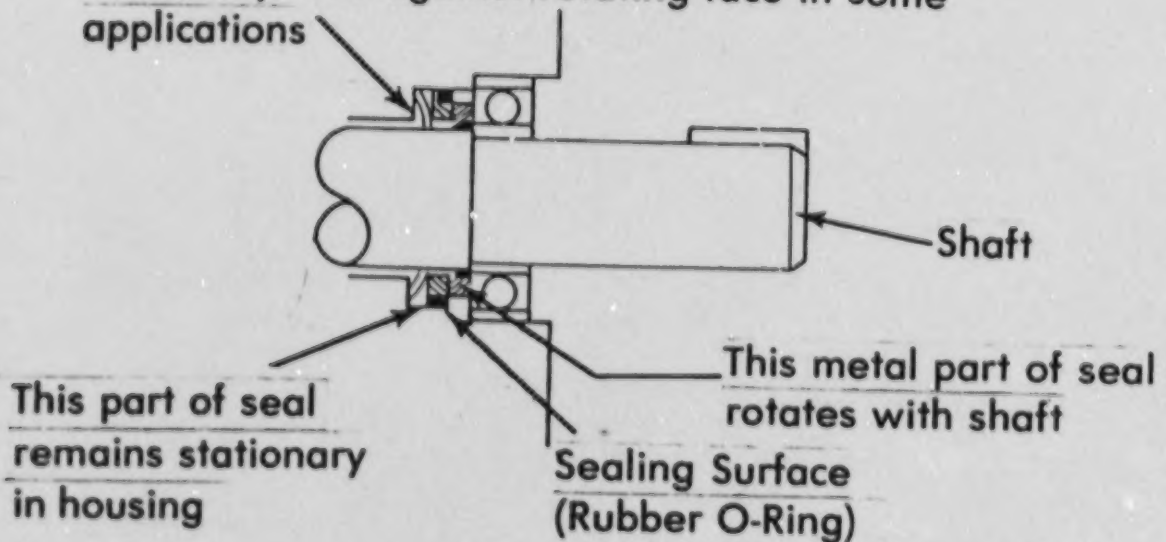
Cup Seal

Cup seals are pressure activated.



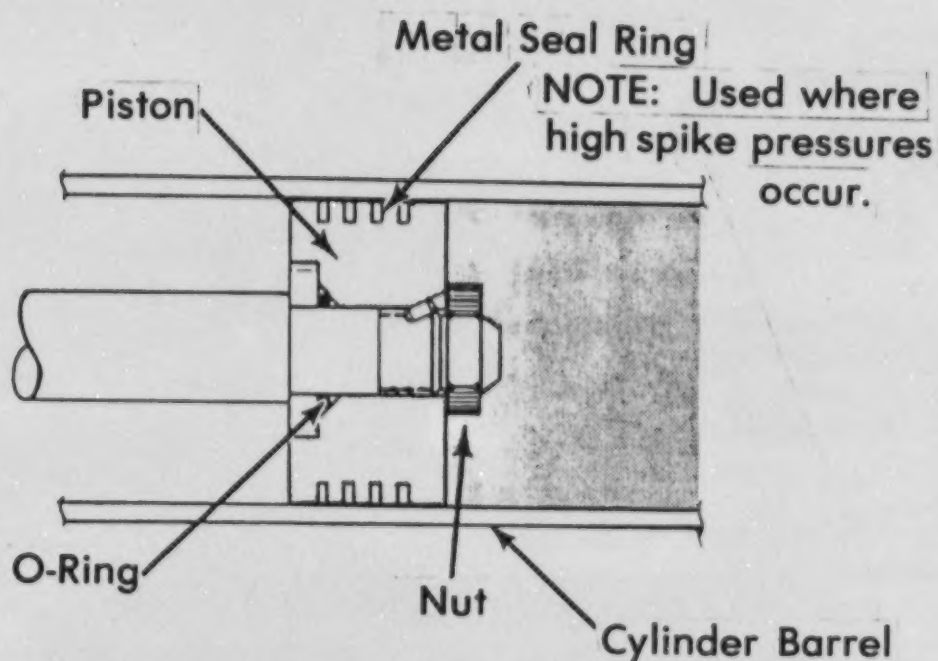
Face Seal

Wave washer provides spring tension to force stationary face against rotating face in some applications



Types of Seal Construction

Piston Ring



LESSON PLAN: 6

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

DEMONSTRATION LESSON: II-6

INSTALL AN O-RING
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Remove an O-ring.
2. Clean and inspect component sealing surfaces.
3. Repair any damaged areas as noted from inspection.
4. Reclean any damaged areas where repair was needed.
5. Install O-ring and reassemble component.
6. Test component for proper leakage-free operation.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

INFORMATIONAL ASSIGNMENT: (Student)

None

REFERENCES: (Instructor's Additional Information)

None

INTRODUCTION:

Replacing an O-ring can prevent accidents (slipping on oily floor), conserve oil, and can prevent many other related problems.

LESSON PLAN: 6

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-6

TOOLS, EQUIPMENT, AND MATERIALS:

Wrenches as required

O-ring remover tool (brass or soft metal)

Fitting assembly which uses an O-ring seal

(NOTE: Other components which use O-rings seals may be used.)

O-ring of appropriate size

Abrasive material such as emery cloth

STEPS OF PROCEDURE:

- I. Clean dirt and other foreign material from assembly.
- II. Disassemble fitting (or other component) to access the O-ring.
- III. Remove O-ring.
- IV. Inspect.

(NOTE: After completing each point in the inspection, check the appropriate box and briefly describe the condition of the components.)

	✓	Condition
A. Inspect O-ring groove.		
B. Remove sharp edges, nicks, or burrs with a fine abrasive stone or emery paper. (NOTE: Extreme care should be taken with this operation.)		
C. Inspect shaft or spool for sharp edges.		
D. Remove nicks or burrs with abrasive material.		
E. Polish with a fine corcus cloth and light lubricant.		

V. Reclean assembly, removing any debris from above inspection

VI. Install O-ring

- A. Lubricate O-ring (using oil that is used in the system if possible).
- B. Protect O-ring from sharp edges.
- C. If necessary, cover sharp edges with a thin plastic shim during installation.

(NOTE: Avoid twisting O-ring during installation.)

VII. Reassemble

- A. Align parts and reassemble.
- B. During reassembly, observe that the O-ring is properly seated and not cut or twisted.

(NOTE: Only a slight squeeze should be applied to the O-ring. Normally, the component will be cycled for a few cycles and then visually inspected for leakage. This operation will not be performed at this time.)

VIII. Have instructor inspect.

LESSON PLAN: 6

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-6

INTERACTION ITEMS: (Review Items)

1. An O-ring can be used as a dynamic and static seal in a hydraulic and pneumatic cylinder.

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES

LESSON PLAN: 6

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-6

EVALUATION ITEMS:

The student has satisfactorily completed the following steps of procedure:

- I. Remove O-ring.
- II. Clean and inspect component sealing surfaces.
- III. Repair any damaged areas as noted from inspection.
- IV. Reclean any damaged areas where repair was needed.
- V. Install O-ring and reassemble component.
- VI. Test component for proper leakage-free operation.

Yes No

Instructor's Signature
(Verifying Satisfactory Completion)

Date

LESSON PLAN: 7

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

DEMONSTRATION LESSON: II-7

INSTALL A MECHANICAL SEAL
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Remove old seal.
2. Clean and inspect seal mounting.
3. Reinstall new seal.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

INFORMATIONAL ASSIGNMENT: (Student)

REFERENCES: (Instructor's Additional Information)

INTRODUCTION:

Seals can be damaged by incorrect installation or by improper removal of the old seal, causing damage to seal mounting surfaces.

LESSON PLAN: 7

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-7

TOOLS, EQUIPMENT, AND MATERIALS:

Wrenches as required

Seal installation tool (if required)

Cylinder which uses a wiper seal such as front timing chain cover

Wiper seal, or seal to be used

Abrasive material such as emery cloth

STEPS OF PROCEDURE:

(NOTE: This procedure may also be used for pressure type seals.)

- I. Clean cylinder rod and end cap.
- II. Remove end cap.
- III. Remove old seal.

(NOTE: Observe direction of lip. Be careful not to damage mounting area.)

- IV. Clean shaft and bore of cylinder.
- V. Inspect.

(NOTE: After completing each point in the inspection, check the appropriate box and briefly describe the condition of the components.)

		Condition
A. Check shaft for nicks and burrs.		
B. Repair damaged area with abrasive material. (NOTE: Chrome must be removed before repairs can be made locally or totally.)		
C. Polish with fine emery cloth.		
D. Reclean.		

- VI. Lubricate seal with recommended lubricant to ease installation.
(NOTE: Lubricate lip area only.)
- VII. Load seal onto shaft.
 - A. Use plastic shim to protect seal from sharp edges.
 - B. Insure that the seal is oriented properly.
- VIII. Coat outside diameter of metal-cased seals with gasket cement to prevent leakage.
- IX. Seat seal.
(NOTE: Press-fit seals may require the use of a special tool to press the seal in place.)
- X. Insure that the seal is securely installed.
- XI. Reinstall end cap.
(NOTE: Normally, the cylinder will be cycled for a few cycles then visually inspected for leakage. This operation will not be performed at this time.)
- XII. Have instructor inspect.

LESSON PLAN: 7

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-7

INTERACTION ITEMS: (Review Items)

1. Lip-type seals can be either dynamic or static seals.

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

None

LESSON PLAN: 7

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-7

EVALUATION ITEMS:

The student has satisfactorily completed the following steps of procedure:

- I. Removed old seal.
- II. Cleaned and inspected seal mounting area.
- III. Installed new seal.
- IV. Tested for proper operation and leakage.

Yes ____ No ____

Instructor's Signature
(Verifying Satisfactory Completion)

Date

LESSON PLAN: 8

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

INFORMATION TOPIC: II-8

FILTERS
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Match terms associated with filters with the correct definitions.
2. Select the effects of contaminants in the hydraulic system.
3. List practices for assuring hydraulic system cleanliness.
4. Select functions of the filter in a hydraulic system.
5. Distinguish between surface filters and depth filters.
6. Match the locations with the types of filters in the hydraulic system.
7. Identify types of filter circuits.
8. Select factors used in specifying a filter.
9. Draw the symbol for a filter.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Types of Filters
2. TM 2: Locations of Filters in Hydraulic System
3. TM 3: Types of Filter Circuits

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979, Chap. 7.

REFERENCES: (Instructor's Additional Information)

Fluid Power Designer's Lightning Reference Handbook. Orange, CA: Paul-Munroe Hydraulics, Inc., 1976.

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979.
Pippinger, John, and Tyler Hicks. Industrial Hydraulics. New York: McGraw-Hill Book Company, 1979.

INTRODUCTION:

Contaminated oil can scar or completely freeze a precisely fitted valve spool on a hydraulic pump. Measured in dollars and cents, it is cheaper to buy a good filter, maintain it properly, and keep your oil clean than it is to replace a pump or a valve that is worn out by contamination.

LESSON PLAN: 8

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-8

OUTLINE: (Key Points)

I. Terms and definitions

- A. **Contaminant** - any unwanted material in the hydraulic system

(NOTE: This includes various chemicals and particles such as metal, rust, sand, and water.)

- B. **Particulate contaminant** - contaminant which is composed of particles

- C. **Filter** - a device which removes particulate contaminants from hydraulic systems

- D. **Strainer** - a very coarse filter typically used to prevent large items such as rocks and bolts from entering the system

- E. **Viscosity** - a measure of the fluid's resistance to flow

(NOTE: The viscosity will vary as temperature varies.)

- F. **Micron** - a measure of size equal to one millionth of a meter

(NOTE: Micron size is often used to describe the size of particles which a filter will remove from the fluid. For example, a 10 micron absolute filter is said to remove all particles greater than 10 microns.)

- G. **Beta ratings** - number of particles of micron size upstream of element divided by the number downstream

II. Effects of contaminants in the hydraulic system

- A. **Reduced component life**

(NOTE: Even small amounts of contaminant in the system may wear out a hydraulic pump in as little as a few hours.)

- B. **Scored internal surfaces**

(NOTE: Scored internal surfaces can result in excess leakage and poor performance.)

- C. **Clogged internal passages**

- D. **Seized components**

- E. Poor performance
- F. Improper operation

(NOTE: One teaspoon of dust in 55 gallons of oil is a dirty system.)

III. Practices for assuring hydraulic system cleanliness

- A. Change fluid and filter as required.
- B. Fill system only with clean filtered fluid.

(NOTE: Factory fresh oil is often quite dirty.)

- C. Clean dirt off breather caps and filler plugs prior to opening system.
- D. Use a clean, lint-free towel to wipe dipstick.

- E. Replace worn seals.

(NOTE: Worn wiper seals on cylinders can allow a large amount of dirt to enter the system through the cylinder.)

- F. Keep work area clean.

(NOTE: This is especially important when disassembling components such as pumps.)

- G. Clean and flush components prior to installing in system.

IV. Functions of the filter in a hydraulic system

- A. To remove dirt that has entered the system through breather caps, seals, open lines, and unclean components
- B. To remove metal particles generated by wear processes
- C. To remove particles resulting from rust or corrosion of internal surfaces

V. Types of filters (TM 1)

- A. Surface filter - has a single surface that catches and removes dirt particles larger than the holes in the filter
- B. Depth filter - uses a large volume of filter material to trap the particles as the oil passes through

(NOTE: This filter material is similar to cotton.)

VI. Locations of filters in the hydraulic system (TM 2)

- A. Strainer or suction line filter - inlet of the pump

(NOTE: An inlet strainer is used only to prevent large objects such as nuts, bolts, and metal chips from entering the pump.)

- B. Pressure line filter - in pressure line

- C. Return line filter - return line between outlet of load and reservoir

VII. Types of filter circuits (TM 3)

- A. Full flow filter

- B. Partial flow filter

- C. Auxiliary flow filter

VIII. Factors used in specifying a filter

- A. Degree of filtration (performance)

(NOTE: This is commonly expressed as an efficiency or as minimum size particle removed, usually in the unit microns.)

- B. Flow rate

- C. Pressure drop

- D. Dirt capacity

- E. System pressure

- F. Operating temperature

IX. Symbol for a filter



(NOTE: This symbol is also used for a strainer.)

LESSON PLAN: 8

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-8

INTERACTION ITEMS: (Review Items)

1. One micron is 40 millionth of one inch. How many particles laid side by side would equal one inch? Answer - 25,000.

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES

LESSON PLAN: 8

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-8

EVALUATION

1. Match the terms on the right with the correct definitions.

- | | | |
|-----------------------------|---|----------------------------|
| ☐ a. | Any unwanted material in the hydraulic system | 1. Strainer |
| ☐ b. | Contaminant which is composed of particles | 2. Contaminant |
| ☐ c. | A device which removes contaminants from hydraulic systems | 3. Viscosity |
| ☐ d. | A very coarse filter typically used to prevent large items such as rocks and bolts from entering the system | 4. Filter |
| ☐ e. | A measure of the fluid's resistance to flow | 5. Micron |
| ☐ f. | A measure of size equal to one millionth of a meter | 6. Particulate contaminant |

2. Select the effects of contaminants on hydraulic systems by placing an "X" in the appropriate blanks.

- ☐ a. Clogged internal passages
- ☐ b. Better performance
- ☐ c. Smooth internal surfaces
- ☐ d. Improper operation
- ☐ e. Reduced component life
- ☐ f. Better availability of parts
- ☐ g. Scored internal surfaces

- _____ h. Seized components
3. List five practices for assuring hydraulic system cleanliness.
- a.
 - b.
 - c.
 - d.
 - e.
4. Select functions of the filter in a hydraulic system by placing an "X" in the appropriate blanks.
- _____ a. To remove rocks and bolts in the hydraulic fluid
 - _____ b. To remove particles resulting from rust or corrosion of internal surfaces
 - _____ c. To remove water in the oil
 - _____ d. To remove metal particles generated by wear processes
 - _____ e. To remove dirt that has entered the system through breather caps, seals, open lines, and unclean components
5. Distinguish between surface filters and depth filters by placing an "X" next to the description of depth filters.
- _____ a. Has a single surface that catches and removes dirt particles larger than the holes in the filter
 - _____ b. Uses a large volume of filter materials to trap the particles as the oil passes through
6. Match the locations on the right with the correct filters.
- | | |
|--|---|
| _____ a. Pressure line filter | 1. Inlet of the pump |
| _____ b. Return line filter | 2. Outlet of the pump |
| _____ c. Strainer or suction line filter | 3. Return line between outlet of load and reservoir |

7. List types of filter circuits.

a.

b.

c.

8. Select factors used in specifying a filter by placing an "X" in the appropriate blanks.

___ a. Degree of filtration

___ b. Flow rate

___ c. Water pressure

___ d. Dirt capacity

___ e. Pressure drop

___ f. Size of hydraulic lines

___ g. System pressure

___ h. Amount of water in the oil

___ i. Operating temperature

9. Draw the symbol for a filter

LESSON PLAN: 8

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

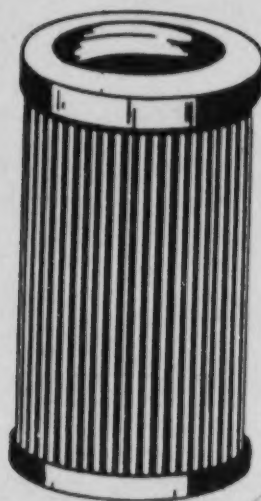
INFORMATION TOPIC: II-8

ANSWERS TO EVALUATION

1.
 - a. 2
 - b. 6
 - c. 4
 - d. 1
 - e. 3
 - f. 5
2. a, d, e, g, h
3. Any five of the following:
 - a. Change fluid and filter regularly.
 - b. Fill system only with clean oil.
 - c. Clean dirt off breather caps and filler plugs prior to opening system.
 - d. Use a clean, lint-free towel to wipe dipstick.
 - e. Replace worn seals.
 - f. Keep work area clean.
 - g. Clean and flush components prior to installing in system.
4. b, d, e
5. b
6.
 - a. 2
 - b. 3
 - c. 1
7.
 - a. Full flow filter
 - b. Partial flow filter
 - c. Auxiliary flow filter
8. a, b, d, e, g, i
- 9.



Types of Filters



Surface Filter

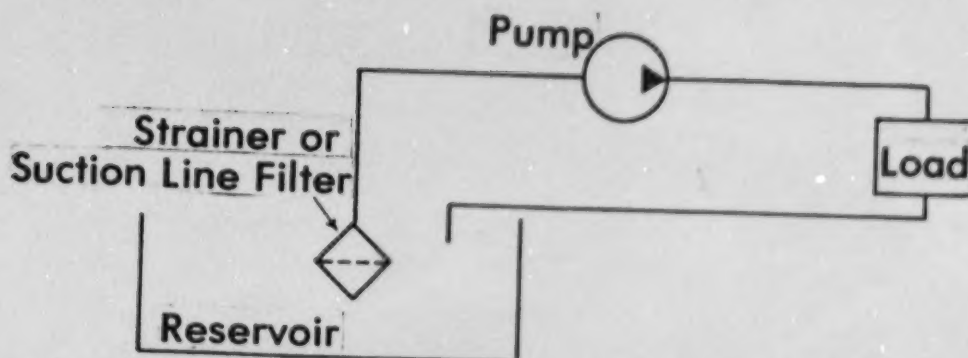
(Pleated Paper, Wire Mesh, or
Stacked Metal Disk)



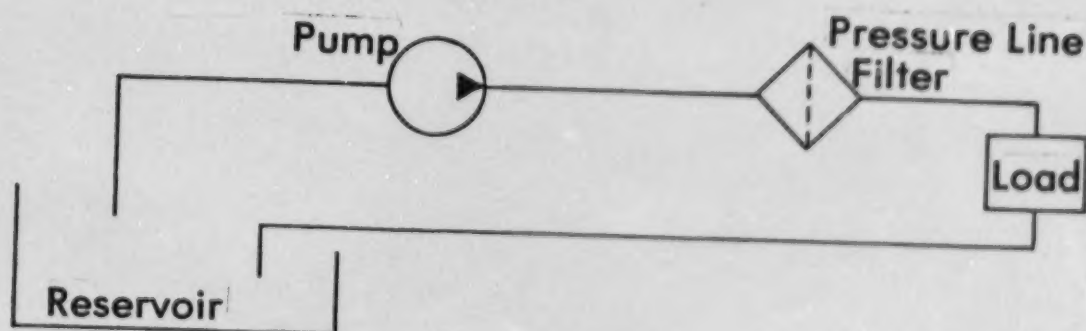
Depth Filter

Location of Filters in Hydraulic System

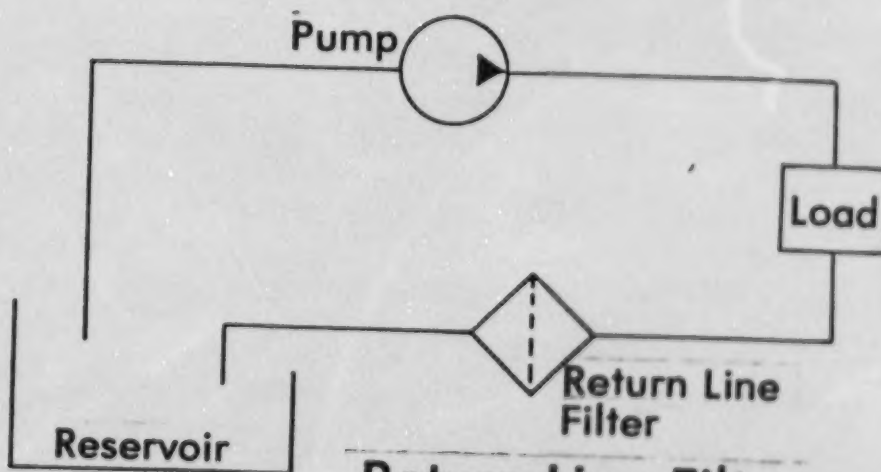
ETM2



Strainer or Suction Line Filter

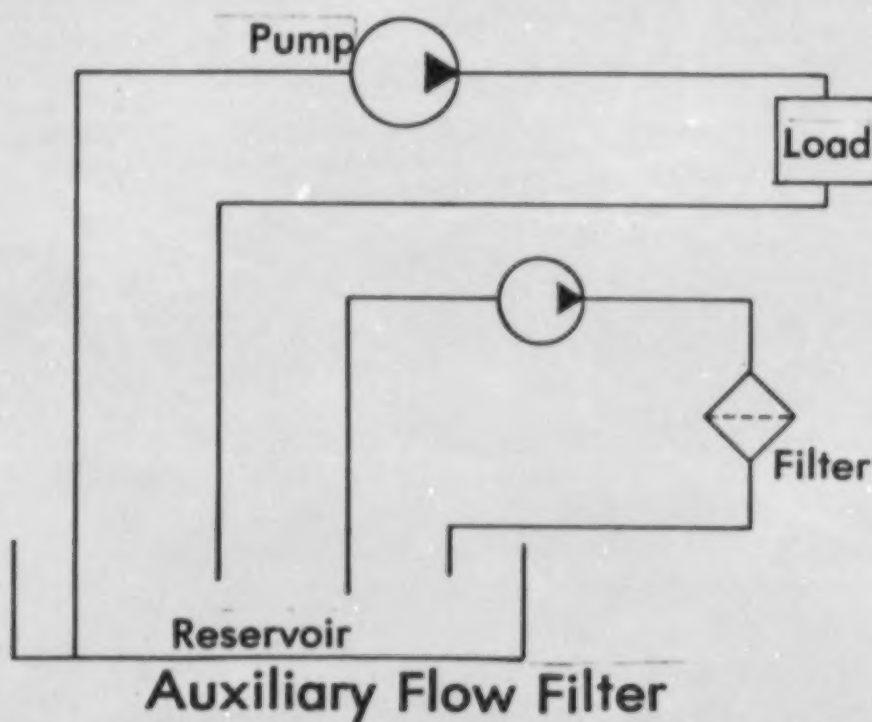
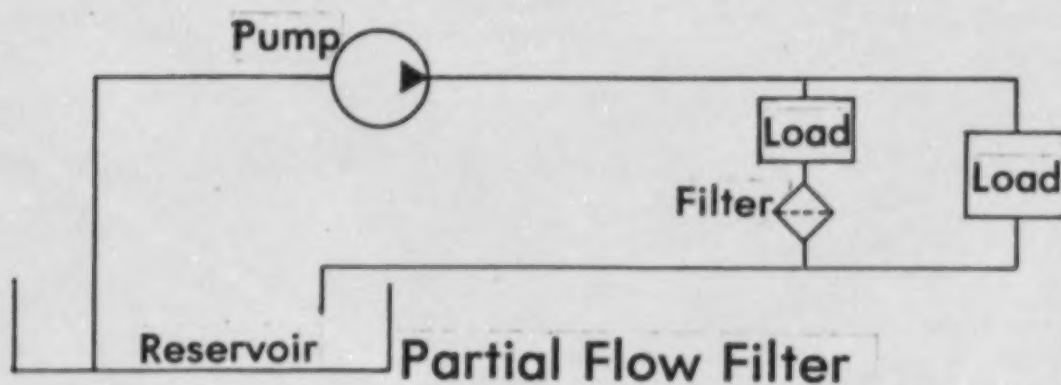
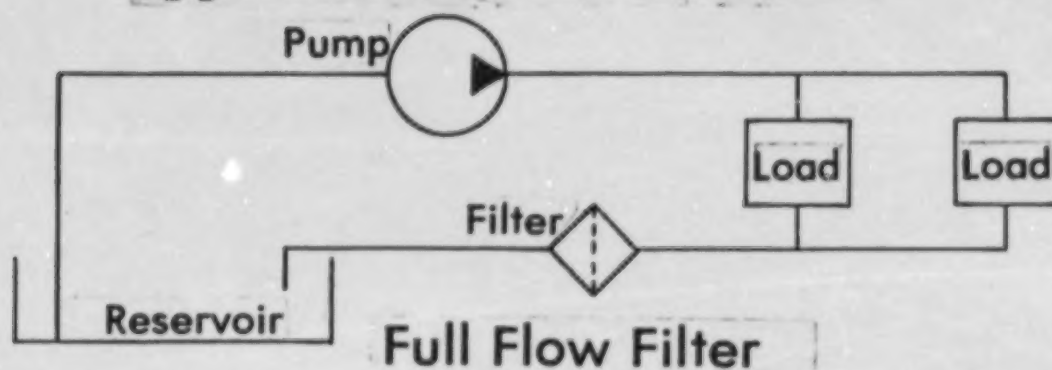


Pressure Line Filter



Return Line Filter

Types of Filter Circuits



LESSON PLAN: 9

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

INFORMATION TOPIC: II-9

HYDRAULIC FLUIDS
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. List four functions of the fluid in hydraulic systems.
2. Select true statements concerning the effect of temperature on the viscosity of hydraulic fluids.
3. Name common additives in hydraulic systems.
4. List common types of fluids.
5. List five safety rules to remember when working with hydraulic fluids.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979, Chap. 10.

REFERENCES: (Instructor's Additional Information)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979.

Pippinger, John, and Tyler Hicks. Industrial Hydraulics. New York: McGraw-Hill Book Company, 1979.

INTRODUCTION:

The hydraulic fluid is the medium by which power is transmitted from a pump to the mechanisms which produce work, such as cylinders and hydraulic motors. When we speak of a hydraulic fluid, in almost all cases we mean a highly refined petroleum oil usually containing additives to suppress some unwanted properties and to give the oil more desirable properties.

LESSON PLAN: 9

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-9

OUTLINE: (Key Points)

- I. Functions of the fluid in hydraulic systems
 - A. Transmit power
 - B. Lubricate system
 - C. Assist in sealing system
 - D. Transport heat
- II. Effect of temperature on the viscosity of hydraulic fluids (TM 1)
 - A. Viscosity will decrease as temperature increases.
 - B. Viscosity will increase as temperature decreases.
 - C. The amount of change in viscosity for a specified change in temperature is known as the viscosity index.
- III. Common additives in hydraulic systems
 - A. Viscosity index improver
 - B. Anti-wear additives
 - C. Anti-oxidation compounds
 - D. Corrosion inhibitors (acid neutralizer and rust inhibitors)
(NOTE: Proper storage can prevent moisture from contaminating good fluid.) (TM 2)
 - E. Anti-foam additives
 - F. Extreme pressure additives
- IV. Common types of fluids
 - A. Petroleum base

- B. Synthetic base
 - C. High-water base
 - D. Water-glycol emulsion
- V. Safety rules to remember when working with hydraulic fluids
- A. Allow the system to cool prior to working on it.
(NOTE: Fluid in a working hydraulic system can be 150°F or higher. These temperatures can cause severe burns.)
 - B. Avoid contact with skin and eyes.
(NOTE: Some hydraulics fluids are very caustic, particularly those used in aircraft.)
 - C. Remove filler cap slowly to relieve any trapped pressure.
(NOTE: Some systems are capable of pressure build up in the reservoir from thermal expansion of the fluid on a hot day. It is possible that you may be sprayed with oil if the pressure is not slowly released.)
 - D. Since many hydraulic fluids are flammable, treat all fluids as flammable material.
(NOTE: Most hydraulic fluids used in industrial and mobile equipment are flammable.)
 - E. Avoid contact with hot objects such as exhaust manifolds.
 - F. Always filter oil prior to adding to system.

LESSON PLAN: 9

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-9

INTERACTION ITEMS: (Review Items)

1. How can rust and corrosion be present in a hydraulic system?
2. Proper storage is an important step in maintaining good fluid.

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

LESSON PLAN: 9

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-9

EVALUATION

1. List four functions of the fluid in hydraulic systems.
 - a.
 - b.
 - c.
 - d.
2. Select true statements concerning the effect of temperature on the viscosity of hydraulic fluids by placing an "X" in the appropriate blanks.
 - ☐ a. Viscosity will decrease as temperature increases.
 - ☐ b. Viscosity will increase as temperature increases.
 - ☐ c. Viscosity will decrease as temperature decreases.
 - ☐ d. Viscosity will increase as temperature decreases.
 - ☐ e. The amount of change in viscosity for a specified change in temperature is known as the viscosity index.
3. Name three common additives in hydraulic systems.
 - a.
 - b.
 - c.

4. List common types of hydraulic fluids.
 - a.
 - b.
 - c.
 - d.
5. List five safety rules to remember when working with hydraulic fluids.
 - a.
 - b.
 - c.
 - d.
 - e.

LESSON PLAN: 9

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-9

ANSWERS TO EVALUATION

1.
 - a. Transmit power
 - b. Lubricate system
 - c. Assist in sealing system
 - d. Transport heat
2. a, d, e
3. Any three of the following:
 - a. Viscosity index improver
 - b. Anti-wear additives
 - c. Anti-oxidation compounds
 - d. Corrosion inhibitors
 - e. Anti-foam additives
4.
 - a. Petroleum base
 - b. Synthetic base
 - c. High-water base
 - d. Water-glycol emulsion
5.
 - a. Allow the system to cool prior to working on it.
 - b. Avoid contact with skin and eyes.
 - c. Remove filler cap slowly to relieve any trapped pressure.
 - d. Since many hydraulic fluids are flammable, treat all fluids as flammable material.
 - e. Avoid contact with hot objects such as exhaust manifolds.

LESSON PLAN: 10

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

INFORMATION TOPIC: II-10

INTRODUCTION TO PUMPS
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Match terms related to pumps with the correct definitions.
2. Distinguish between positive and nonpositive displacement pumps.
3. Name kinds of positive displacement pumps.
4. Given the formula, calculate pump displacement.
5. Given the formula, calculate pump flow rate.
6. Given the formulas, calculate pump input and output power.
7. Calculate pump volumetric efficiency.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. AS 1: Calculate Pump Displacement, Flow Rate, Input and Output Power, and Overall Efficiency

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979, Chap. 2.

REFERENCES: (Instructor's Additional Information)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979.

Industrial Hydraulics Manual. 935100-A. Troy, MI: Sperry-Rand Corporation, 1970.

INTRODUCTION:

The pump is the heart of the hydraulic system. It creates the flow of fluid which supplies the whole circuit. A hydraulic pump is one that moves fluid and induces fluid to work. A pump converts mechanical force into hydraulic fluid power.

LESSON PLAN: 10

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-10

OUTLINE: (Key Points)

I. Terms and definitions

- A. **Pump** - a device which creates the flow of fluid
- B. **Displacement** - the volume of fluid which is transferred from the pump inlet to the outlet during one revolution of the pump
- C. **Volumetric efficiency** - the actual flow rate from a pump divided by the theoretical flow rate

(NOTE: The theoretical flow rate is calculated using

$$Q = \frac{n \times d}{231}$$

Where Q is the theoretical flow rate in gpm,
n is the speed in revolutions per minute, and
d is the displacement in cubic inches.

Efficiency is often expressed as a percentage.)

II. Types of pumps

- A. **Positive displacement** - a pump whose inlet is sealed from the outlet; will deliver fluid any time the inlet is kept supplied and the pump is driven
- B. **Nonpositive displacement** - a pump whose inlet and outlet are hydraulically connected so that the fluid can recirculate in the pump when pressure builds up

(NOTE: Formula does not apply)

III. Kinds of positive displacement pumps

- A. Gear
- B. Vane

C. Piston

D. Screw

IV. Formula for calculation of pump displacement

$$d = \frac{231Q}{n}$$

where d = displacement in $\text{in}^3/\text{revolution}$
 Q = pump outlet flow rate in gallons per minute (gpm)
 n = pump speed in revolutions per minute (rpm)

Example: A pump which has an outlet flow of 20 gpm at 1800 rpm has a displacement of $2.56 \text{ in}^3/\text{rev}$

$$d = \frac{231 \times 20 \text{ gpm}}{1800 \text{ RPM}} = 2.56 \text{ in}^3/\text{rev}$$

V. Formula for calculation of pump flow rate

$$Q = \frac{n \times d}{231}$$

Example: A $2.56 \text{ in}^3/\text{rev}$. pump operating at 2400 rpm has a flow rate of 26.6 gpm

$$Q = \frac{2400 \times 2.56}{231} = 26.6 \text{ gpm}$$

VI. Formula for calculation of pump power

A. Output power

$$\text{Power} = \frac{P \times Q}{1714}$$

where Power = Output power in horsepower
 P = Outlet pressure in psi
 Q = Outlet flow in gpm

Example: A pump operating with 20 gpm flow and 3000 psi outlet pressure has output power of 35 hp

$$\text{Power} = \frac{3000 \text{ psi} \times 20 \text{ gpm}}{1714} = 35 \text{ hp}$$

B. Input power

$$\text{Power} = \frac{n \times \text{Torque}}{5252}$$

where Power = Input power in horsepower
 Torque = Input shaft torque in ft./lbs
 n = Speed in rpm

Example: A pump operating at 2400 rpm with a shaft torque of 70 ft.lbs. has input power of 32 hp

$$\text{Power} = \frac{(2400\text{rpm})(70 \text{ ft.lbs})}{5252} = 32 \text{ hp}$$

VII. Formula for calculation of volumetric efficiency

$$\text{Volumetric Eff} = \frac{\text{Actual flow rate}}{\text{theoretical flow rate}}$$

Example: The outlet flow rate of a 2.56 in³/rev pump operating at 2400 rpm is measured to be 22.5 gallons per minute (gpm). The volumetric efficiency is 84.4%.

$$\text{Theoretical flow rate} = \frac{n \times d}{231} = \frac{2400 \text{ rpm} \times 2.56 \text{ in}^3/\text{rev}}{231} = 26.6 \text{ gpm}$$

$$\text{Volumetric Eff} = \frac{22.5 \text{ gpm}}{26.6 \text{ gpm}} = 0.846$$

LESSON PLAN: 10

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-10

INTERACTION ITEMS: (Review Items)

1. What device creates flow of fluid?

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES

ASSIGNMENT SHEET 1: CALCULATE PUMP DISPLACEMENT, FLOW RATE, INPUT AND OUTPUT POWER, AND OVERALL EFFICIENCY

Directions: Solve the following problems using the formula which applies to that problem.

$$\text{Pump displacement} = d = \frac{231 Q}{n}$$

$$\text{Pump flow rate} = Q = \frac{n \times d}{231}$$

$$\text{Pump output power} = \text{hp} = \frac{P \times Q}{1714}$$

$$\text{Pump input power} = \text{hp} = \frac{n \times \text{Torque}}{5252}$$

$$\text{Pump overall efficiency} = \frac{\text{Output power}}{\text{Input power}}$$

- a. What is the pump displacement when the flow rate is 23 gpm at 1900 rpm?
- b. What is the flow rate of a $3.0 \text{ in}^3/\text{rev.}$ pump operating at 2600 rpm?
- c. What is the output power of a pump with 21 gpm flow and 3200 psi outlet pressure?
- d. What is the input power of a pump operating at 2500 rpm with a shaft torque of 70 ft.lbs?
- e. What is the overall efficiency of a pump if the output power is 40 hp and the input power is 46 hp?
- f. What is the flow rate of a $3.12 \text{ in}^3/\text{rev.}$ pump operating at 2200 rpm?
- g. What is the input power of a pump operating at 3000 rpm with a shaft torque of 75 ft.lbs?
- h. What is the pump displacement if the outlet flow is 26 gpm at 2000 rpm?
- i. What is the output power of a pump with a 25 gpm flow and 3000 psi pressure?

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet 1:

- a. $2.79 \text{ in}^3/\text{rev.}$
- b. 34 GPM
- c. 39 HP
- d. 33 HP
- e. 87%
- f. 29.7 GPM
- g. 43 HP
- h. $3 \text{ in}^3/\text{rev.}$
- i. 44 HP

LESSON PLAN: 10

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-10

EVALUATION

1. Match the terms on the right with the correct definitions.

- | | | |
|--------|--|--------------------------|
| ___ a. | A device which creates the flow of fluid | 1. Displacement |
| ___ b. | The volume of fluid which is transferred from the pump inlet to the outlet during one revolution of the pump | 2. Pump |
| ___ c. | The actual flow rate from a pump divided by the theoretical flow rate | 3. Volumetric efficiency |

2. Distinguish between positive and nonpositive displacement pumps by placing an "X" next to the description of positive displacement pumps.

- ___ a. A pump whose inlet and outlet are hydraulically connected so that fluid can recirculate in the pump when pressure builds up
- ___ b. A pump whose inlet is sealed from the outlet; will deliver fluid any time the inlet is kept supplied and the pump is driven.

3. Name three kinds of positive displacement pumps.

a.

b.

c.

4. Calculate the pump displacement for a pump which has an outlet of 30 gpm at 200 rpm, using the formula for displacement, $d = \frac{231 Q}{n}$.

5. Calculate the flow rate for a $2.88 \text{ in}^3/\text{rev.}$ pump operating at 2000 rpm using the formula for flow rate, $Q = \frac{n \times d.}{231}$

6. a. Calculate the output power for a pump operating with 18 gpm flow and 2700 psi outlet pressure using the formula, $\text{Power} = \frac{P \times Q.}{1714}$

- b. Calculate the input power for a pump operating at 2000 rpm with a shaft torque of 50 ft.lbs. using the formula, $\text{Power} = \frac{n \times \text{Torque.}}{5252}$

7. Calculate the volumetric efficiency of a $2.56 \text{ in}^3/\text{rev.}$ pump operating at 2300 rpm with an outlet flow rate of 22 gallons per minute (gpm).

LESSON PLAN: 10

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-10

ANSWERS TO EVALUATION

1.
 - a. 3
 - b. 1
 - c. 4
 - d. 5
 - e. 6
 - f. 2
2. b
3. Any three of the following:
 - a. Gear
 - b. Vane
 - c. Piston
 - d. Screw
4. $3.465 \text{ in}^3/\text{rev.}$
5. 24.9 GPM
6.
 - a. 28 HP
 - b. 19 HP
7. 86%

LESSON PLAN: 11

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

INFORMATION TOPIC: II-11

PUMP OPERATION
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Discuss the operation of a gear pump.
2. Select true statements concerning the operation of vane pumps.
3. Distinguish between an axial and a radial piston pump.
4. Select true statements concerning the operation of a radial piston pump.
5. Name two types of axial piston pumps.
6. Discuss the construction and operation of axial piston pumps.
7. Select true statements concerning the operation of a variable displacement axial piston pump.
8. Identify the parts of a servo-controlled variable displacement pump.
9. Match the components of pressure compensated axial piston pumps with their functions.
10. List four causes of hydraulic pump cavitation.
11. List common causes of hydraulic pump failure.
12. Draw the symbols for types of pumps.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Gear Pump
2. TM 2: Vane Pumps
3. TM 3: Types of Piston Pumps
4. TM 4: Construction and Operation of Axial Piston Pumps
5. TM 5: Bent-Axis Axial Piston Pump - Fixed Displacement
6. TM 6: Operation of Variable Displacement Axial Piston Pump
7. TM 7: Parts of a Servo-Controlled Variable Displacement Pump (Bi-Directional)
8. TM 8: Operation of Pressure Compensated Axial Piston Pumps (Uni-Directional)

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979, Chap. 2.

REFERENCES: (Instructor's Additional Information)

Fluid Power 1. Cleveland, OH: Parker-Hannifin Corporation, 1975.

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979.

Industrial Hydraulics Manual. 935100-A. Troy, MI: Sperry-Rand Corporation, 1970.

INTRODUCTION:

Pumps differ in operation, due to the various designs. Gear pumps, piston pumps, and vane pumps, though different in design and operation, create flow and are classified as pumps.

LESSON PLAN: 11

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-11

OUTLINE: (Key Points)

I. Operation of a gear pump (TM 1)

- A. The gear pump consists of two or more gears
 - 1. Drive gear - power from engine or motor is applied to this gear
 - 2. Driven gear - rotation of drive gear also causes rotation of driven gear
- B. As the gears pass the inlet of the pump, the space between the gear teeth fills with fluid.
- C. The rotation of the gears carries the fluid around the outside perimeter of the gears to the outlet.

II. Construction and operation of vane pumps (TM 2)

- A. Fixed displacement
 - 1. A fixed displacement vane pump consists of a slotted rotor inside a circular chamber.
 - 2. The chamber has inlet and outlet ports for supplying low pressure fluid and expelling pressurized fluid.
 - 3. Vanes are installed into the slots in the rotor and are free to move in a radial direction (that is, towards or away from the center of the rotor).
 - 4. As the rotor rotates, the vanes are forced outward to contact the surface of the circular chamber.
 - 5. The rotor is installed offset (not in the center) in the circular chamber.
 - 6. As the rotor rotates a vane past the inlet port, a volume of fluid is trapped between two vanes.

7. Because the rotor is installed offset in the circular chamber, the volume contained between two rotors becomes smaller and the trapped fluid is expelled from the outlet.

(NOTE: This is the operation of an unbalanced vane pump. A balanced vane pump is similar except it has two inlets and two outlets.)

- B. Variable displacement - the displacement of a vane pump can be changed by changing the position of the rotor in the circular chamber.

(NOTE: Only unbalanced vane pumps may be used as variable displacement pumps.)

III. Types of piston pumps (TM 3)

- A. Axial - pistons are parallel to the axis of the pump.
- B. Radial - pistons are perpendicular to the axis of the pump.

IV. Operation of a radial piston pump (TM 3)

- A. Pistons are installed radially to the pump, or perpendicular to the shaft.
- B. The pistons are driven by a cam on the pump shaft.
- C. As the shaft rotates, the cam moves the pistons.
- D. On the downward stroke of each piston, a spring-loaded valve opens and fluid is drawn into the piston cylinder from the pump inlet.
- E. During the upward stroke the inlet valve is forced closed and another valve directs the oil to the outlet.

V. Types of axial piston pumps

- A. In-line
- B. Bent-axis

VI. Construction and operation of axial piston pumps

A. In-line (TM 3)

1. The pistons are installed in a circular cylinder block. (TM 4)
2. The cylinder block is attached to the pump shaft and rotates with the shaft.
3. The pistons extend out the cylinder block to contact a fixed plate, called the swash plate, which is installed at an angle and does not rotate.

4. As the pump shaft rotates, the cylinder block and pistons also turn.
5. Since the swash plate is fixed (does not rotate) the pistons are forced in and out of the cylinder (TM 4).
6. The pump inlet and outlets are positioned so that fluid is drawn into the cylinder bore from the inlet when the piston is retracted and forced out the outlet when the piston is extended.
7. The port plate (also called valve plate) is a stationary plate which directs the flow in the correct direction.

B. Bent-axis (TM 5)

1. The bent-axis pump consists of a drive member connected to the pump shaft.
2. The pistons are installed in a cylinder block.
3. The cylinder block is mounted at an angle to the pump shaft and drive member.
4. As the pump shaft turns, the drive member and cylinder block are also turned.
5. Since pistons are attached to the drive member, they are forced to reciprocate (move in and out) in the cylinder bore.
6. During the downward stroke (retracting) fluid is pulled into the cylinder bore from the inlet port.
7. During the upward stroke fluid is pushed out of the cylinder bore to the outlet port.

VII. Operation of a variable displacement axial piston pump (TM 6)

- A. The displacement of an axial piston pump can be changed by changing the angle the swash plates makes with the pump shaft.
- B. The displacement is determined by the piston's travel into and out of the cylinder barrel.

(NOTE: A small swash plate angle causes a small amount of piston travel and therefore small displacement. Similarly, a large angle causes large displacement.)
- C. Varying the displacement is a common method of changing the flow rate of a pump when the pump speed (rpm) is fixed.
- D. Hand screws and hydraulic cylinders are two means of varying the swash plate angle.

VIII. Parts of a servo-controlled variable displacement pump (TM 7)

- A. Tilting swash plate
- B. Upper servo cylinder
- C. Lower servo cylinder

(NOTE: The upper and lower servo cylinders are used to position the swash plate to the correct angle and hold it at that angle. Hydraulic cylinders are used because of the very large forces required to move and hold the swash plate.)

- D. Control lever

(NOTE: The control lever is used to set a desired displacement.)

- E. Displacement control valve

(NOTE: When the control lever is moved, the displacement control valve is opened to direct flow to the correct servo cylinder to move the swash plate. As the swash plate moves to the correct position, the linkage connecting the swash plate, control valve, and control lever tends to close the valve. When the swash plate reaches the correct position the valve closes to trap fluid in the two servo cylinders and hold the swash plate in the correct position. This servo system allows the large forces required for moving and holding the swash plate to be controlled by much smaller forces at the control lever.)

- F. Charge pump

(NOTE: Most piston pumps require a charge pump on the inlet. This insures that the cylinders fill with oil and that the pistons maintain contact with the swash plate at all times. Servo-controlled variable displacement pumps also use the charge pump for force (pressure) for the servo system. The charge pump is usually a gear pump which supplies the fluid at the inlet of the piston pump in the range of 25 to 250 psi. The charge pump may be physically a part of the piston pump or may be externally mounted.

IX. Components and functions of pressure compensated axial piston pumps (TM 8)

(NOTE: Many hydraulic systems are designed to operate with a constant pressure at the outlet of the pump. Because the amount of flow required from the pump by the rest of the system may change, the displacement of the pump must be changed. A pump which will automatically change its displacement (in order to keep a constant pressure) is known as a pressure compensated pump.)

- A. Swash plate - varies the displacement of the pump

(NOTE: The term yoke is often used instead of swash plate. Although yoke is a more common term when discussing pressure compensated pumps, either is acceptable.)

- B. Swash plate (yoke) return cylinder - normally holds the pump at full displacement
- C. Servo cylinder - moves and holds the swash plate
- D. Compensator adjustment spring - used to set the compensator pressure, that is, the pressure at the pump outlet
- E. Compensator (servo) valve - controls the flow of oil to the servo cylinder

(NOTE: When the force on the servo valve created by the outlet pressure is exactly balanced by the compensator spring, fluid flow to the servo cylinder is blocked. When the outlet pressure is too low, the valve shifts to allow the fluid in the cylinder to be released to the pump case thus causing the pump displacement to increase. When the outlet pressure is too high, the valve shifts the other direction to allow the fluid from the outlet to flow into the servo cylinder and decrease the displacement.)

- F. Drain to case - drains fluid from the servo cylinder to the pump case

(NOTE: In addition, continuous flow from the pump outlet is maintained through the case. This provides cooling flow for the pump.)

- G. Load pressure (outlet pressure) - used to shift the compensator valve

X. Causes of hydraulic pump cavitation

(NOTE: Cavitation occurs when there is not ample fluid to fill the pumps inlet and air bubbles form. When these bubbles collapse, a small implosion (inward explosion) occurs which tends to erode and destroy the pump's internal surfaces.)

- A. Restriction in the pump inlet line

(NOTE: A restriction in the inlet can cause a drop in the pressure at the pump inlet. This low pressure allows the formation of the air bubbles and thus cavitation.)

- B. Replacing pump inlet lines with lines which are too small

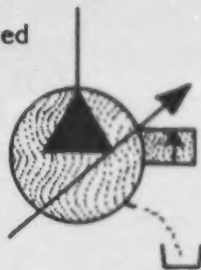
(NOTE: Lines too small can also cause low pressure at the pump inlet.)

- C. Placing reservoir too far from pump

(NOTE: Long lines to the pump can cause low inlet pressure.)

- D. Low fluid level in the reservoir

C. Pressure compensated



D. Directional

1. Bi-directional

- a. Open loop
- b. Closed loop



2. Uni-directional

- a. Open loop
- b. Closed loop



3. Tandem directional



LESSON PLAN: 11

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-11

INTERACTION ITEMS: (Review Items)

1. Although there may not be air leak from the outside, cavitating pumps tend to be filled by gaseous bubbles. When and how are these bubbles formed?
2. Discuss why pumps can fail in a very short time if incorrect liquid is pumped.
3. The causes of hydraulic pump cavitation stated in x have one common physical property they tend to reduce. Name that physical property.

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

LESSON PLAN: 11

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-11

EVALUATION

1. Discuss the operation of a gear pump.

2. Select true statements concerning the operation of vane pumps by placing an "X" next to the statements which are true.
 - ☐ a. A fixed displacement vane pump consists of a slotted rotor inside a circular chamber.
 - ☐ b. In a fixed displacement pump, vanes are installed into the slots in the rotor and are free to move in an axial direction.
 - ☐ c. As the rotor rotates in a fixed displacement pump, the vanes are forced outward to contact the surface of the circular chamber.
 - ☐ d. In a fixed displacement pump, as the rotor rotates a vane past the inlet port, a volume of fluid is trapped between two vanes.
 - ☐ e. Because the rotor is installed offset in the circular chamber in the fixed displacement pump, the volume contained between two rotors becomes smaller and the trapped fluid is expelled from the outlet.
 - ☐ f. The trapped fluid is expelled from the outlet of the pump and is at a lesser pressure than the inlet.
 - ☐ g. In a variable displacement pump, the displacement vane can be changed by changing the position of the rotor in the circular chamber.

3. Distinguish between axial and radial piston pumps by placing an "X" next to the description of an axial piston pump.
 - ☐ a. Pistons are parallel to the axis of the pump.

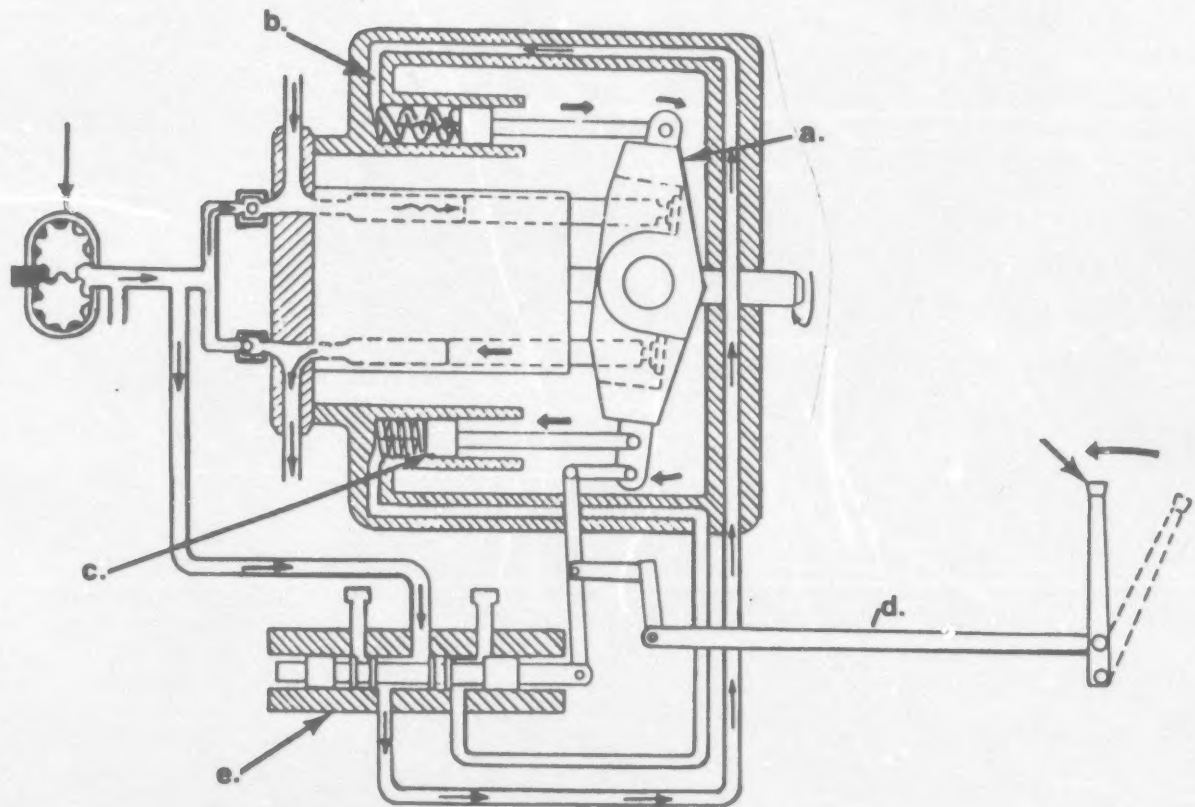
- ____ b. Pistons are perpendicular to the axis of the pump.
4. Select true statements concerning the operation of a radial piston pump by placing an "X" next to the statements which are true.
- ____ a. Pistons are installed radially to the pump.
- ____ b. The pistons are driven by a cam on the pump shaft.
- ____ c. As the shaft rotates, the pistons move the cam.
- ____ d. On the downward stroke of each piston, a spring-loaded valve opens and fluid is drawn into the piston cylinder from the pump inlet.
- ____ e. During the upward stroke the inlet valve is forced closed and another valve directs the oil to the outlet.
5. Name two types of axial piston pumps.
- a.
- b.
6. Discuss the construction and operation of axial piston pumps.
- a. In-line
- b. Bent-axis

7. Select true statements concerning the operation of a variable displacement axial piston pump by placing an "X" next to the statements which are true.

- ☐ a. The displacement of an axial piston pump can be changed by changing the angle the rotor makes with the pump shaft.
- ☐ b. The displacement is determined by the piston's travel into and out of the cylinder barrel.
- ☐ c. Varying the displacement is a common method of changing the flow rate of a pump when the pump speed is fixed.
- ☐ d. Hand screws and hydraulic cylinders are two means of varying the swash plate angle.

8. Identify the parts of a servo-controlled variable displacement pump.

- a. _____
- b. _____
- c. _____
- d. _____
- e. _____
- f. _____



9. Match the components of the pressure compensated axial piston pumps on the right with the correct functions.

- | | | | |
|--------|--|----|-------------------------------|
| ___ a. | Varies the displacement of the pump | 1. | Load pressure |
| ___ b. | Normally holds the pump at full displacement | 2. | Swash plate return cylinder |
| ___ c. | Moves and holds the swash plate | 3. | Compensator adjustment spring |
| ___ d. | Used to set the compensator pressure, that is, the pressure at the pump outlet | 4. | Drain to case |
| ___ e. | Controls the flow of oil to the servo cylinder | 5. | Swash plate |
| ___ f. | Drains fluid from the servo cylinder to the pump case | 6. | Servo cylinder |
| ___ g. | Used to shift the compensator valve | 7. | Compensator valve |

10. List four causes of hydraulic pump cavitation.

- a.
- b.
- c.
- d.

11. List four common causes of hydraulic pump failure.

- a.
- b.
- c.
- d.

12. Draw the symbols for the following pumps.

- a. Fixed displacement

b. Variable displacement

c. Pressure compensated

d. Directional

1. Bi-directional

2. Uni-directional

3. Tandem-directional

LESSON PLAN: 11

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-11

ANSWERS TO EVALUATION

1. Discussion should include:
 - a. The gear pump consists of two or more gears
 - 1) Drive gear - power from engine or motor is applied to this gear
 - 2) Driven gear - rotation of driver gear also causes rotation of driven gear
 - b. As the gears pass the inlet of the pump, the space between the gear teeth fills with fluid
 - c. The rotation of the gears carries the fluid around the outside perimeter of the gears to the outlet
2. a, c, d, e, g
3. a
4. a, b, d, e
5.
 - a. In-line
 - b. Bent-axis
6. Discussion should include:
 - a. In-line
 - 1) The pistons are installed in a circular cylinder block.
 - 2) The cylinder block is attached to the pump shaft and rotates with the shaft.
 - 3) The pistons extend out the cylinder block to contact a fixed plate, called the swash plate, which is installed at an angle and does not rotate.
 - 4) As the pump shaft rotates, the cylinder block and pistons also turn.
 - 5) Since the swash plate is fixed the pistons are forced in and out of the cylinder.
 - 6) The pump inlet and outlets are positioned so that fluid is drawn into the cylinder bore from the inlet when the piston is retracted, and forced out the outlet when the piston is extended.
 - 7) The port plate is a stationary plate which directs the flow in the correct direction.
 - b. Bent-axis
 - 1) The bent-axis pump consists of a drive member connected to the pump shaft.
 - 2) The pistons are installed in a cylinder block.

- 3) The cylinder block is mounted at an angle to the pump shaft and drive member.
- 4) As the pump shaft turns, the drive member and cylinder block are also turned.
- 5) Since pistons are attached to the drive member, they are forced to reciprocate (move in and out) in the cylinder bore.
- 6) During the downward stroke (retracting) fluid is pulled into the cylinder bore from the inlet port.
- 7) During the upward stroke fluid is pushed out of the cylinder bore to the outlet port.

7. b, c, d

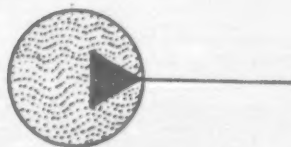
- 8.
- a. Tilting swash plate
 - b. Upper servo cylinder
 - c. Lower servo cylinder
 - d. Control lever
 - e. Displacement control valve
 - f. Charge pump

- 9.
- a. 5
 - b. 2
 - c. 6
 - d. 3
 - e. 7
 - f. 4
 - g. 1

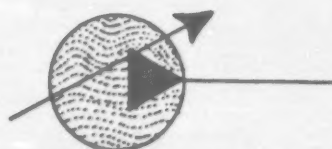
- 10.
- a. Restriction in the pump inlet line
 - b. Replacing pump inlet lines with lines which are too small
 - c. Placing reservoir too far from pump
 - d. Low fluid level in the reservoir

11. Any four of the following:
- a. Contaminated fluid
 - b. Improper fluid
 - c. Improper operating procedures
 - d. Cavitation
 - e. Improper pump maintenance

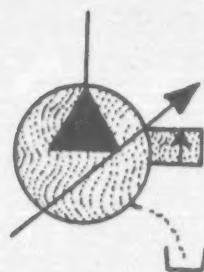
12. a.



b.



c.



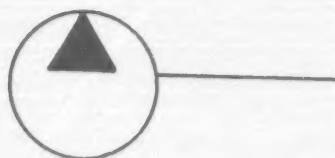
d. 1.



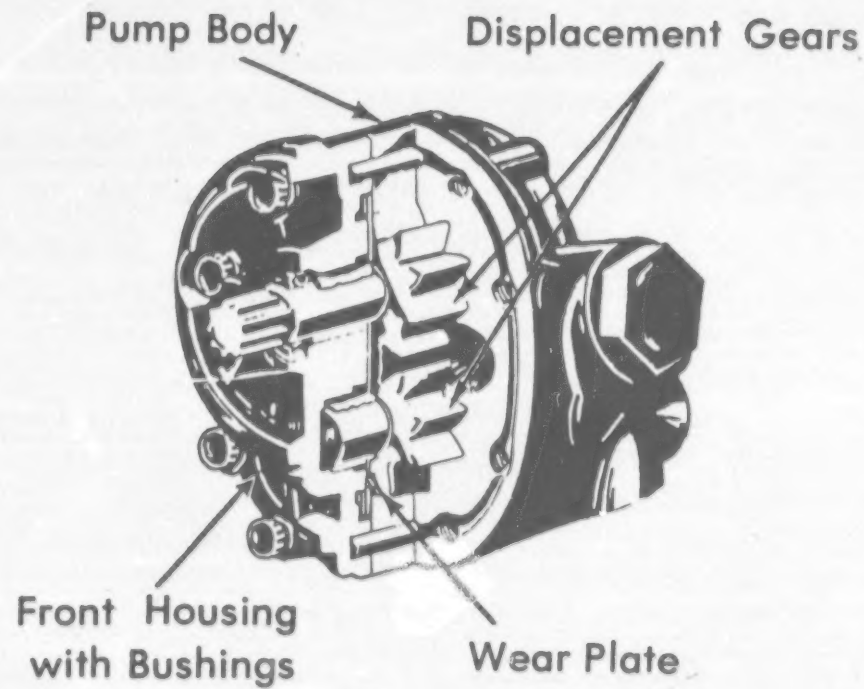
2.



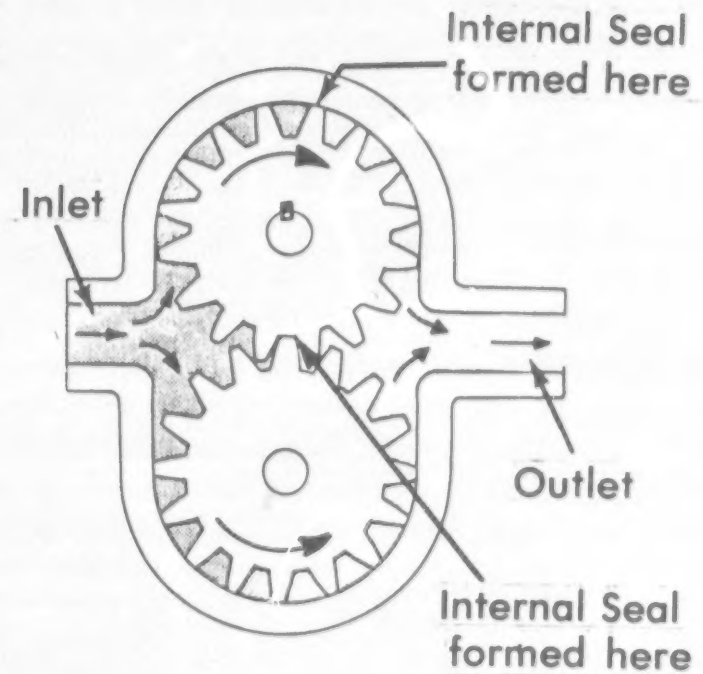
3.



Gear Pump

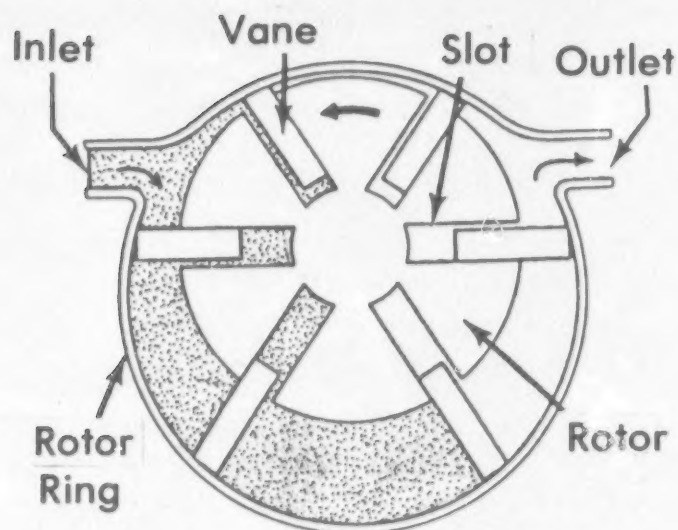


Gear Pump

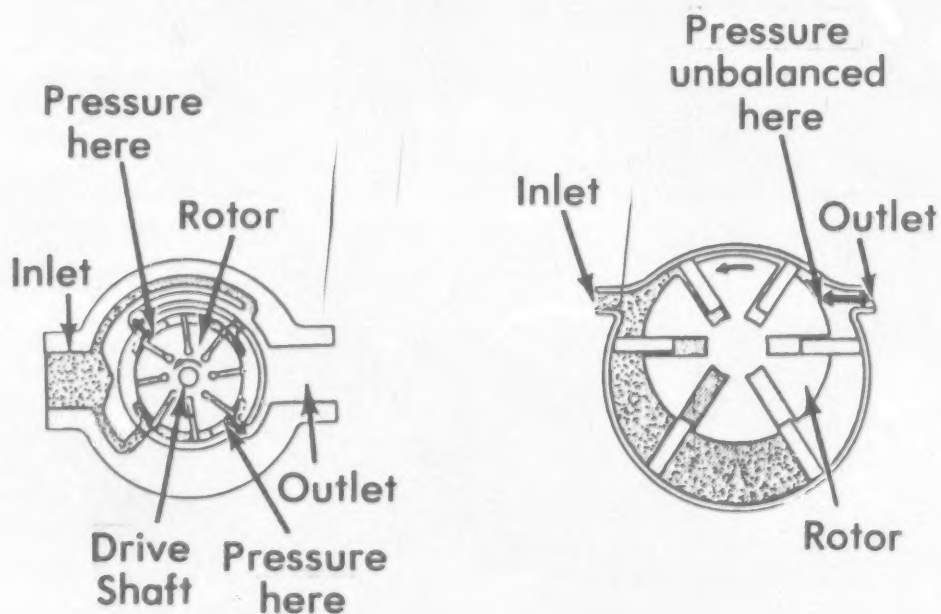


Operation of Gear Pump

Vane Pumps

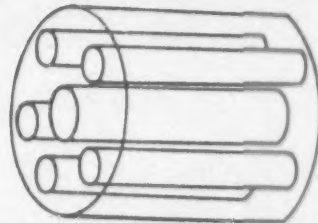


Unbalanced Vane Pump in Operation

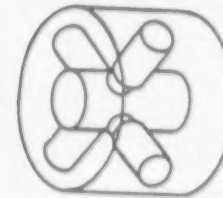


Balanced vs. Unbalanced Vane Pumps— Pressure on Rotor and Shaft

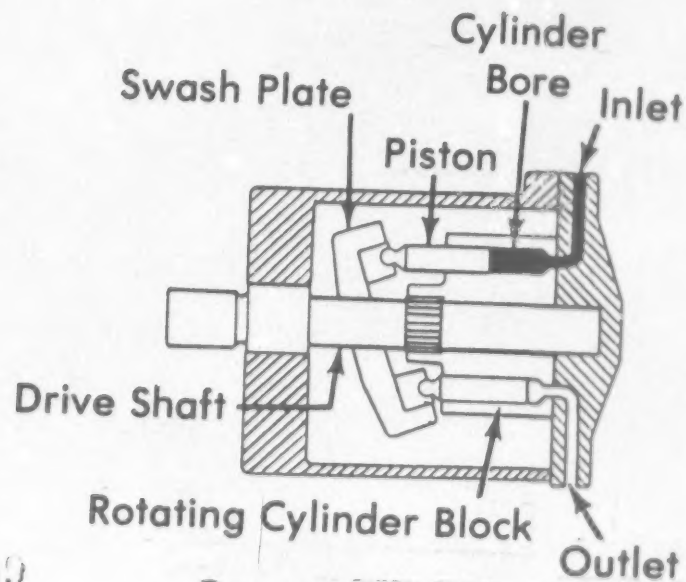
Types of Piston Pumps



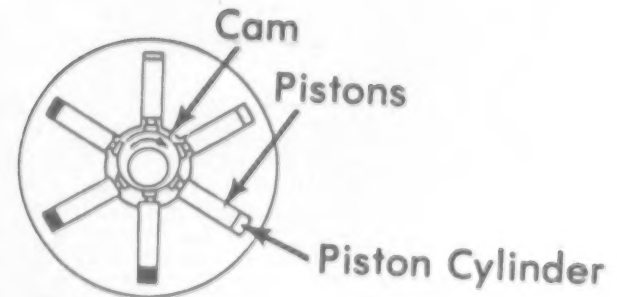
Axial Piston Pump



Radial Piston Pump



Operation of an In-line Axial Piston Pump



Operation of a Radial Piston Pump

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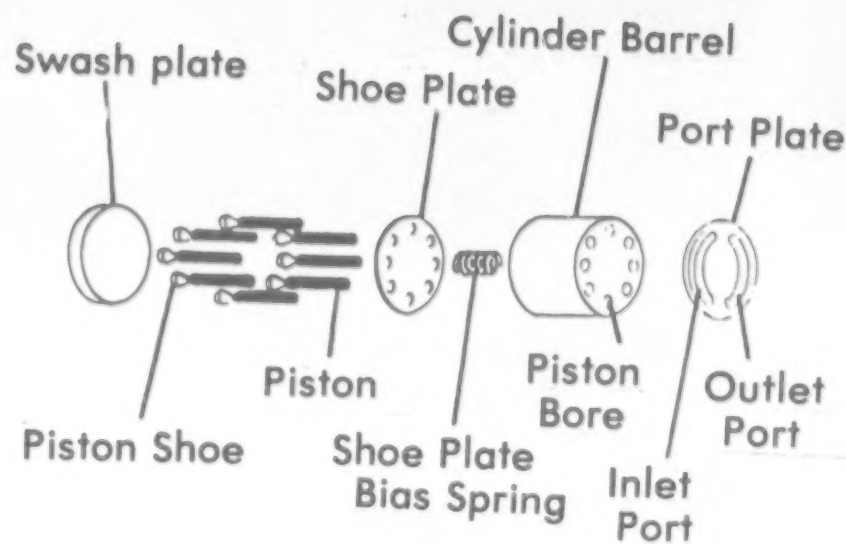
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TM 3

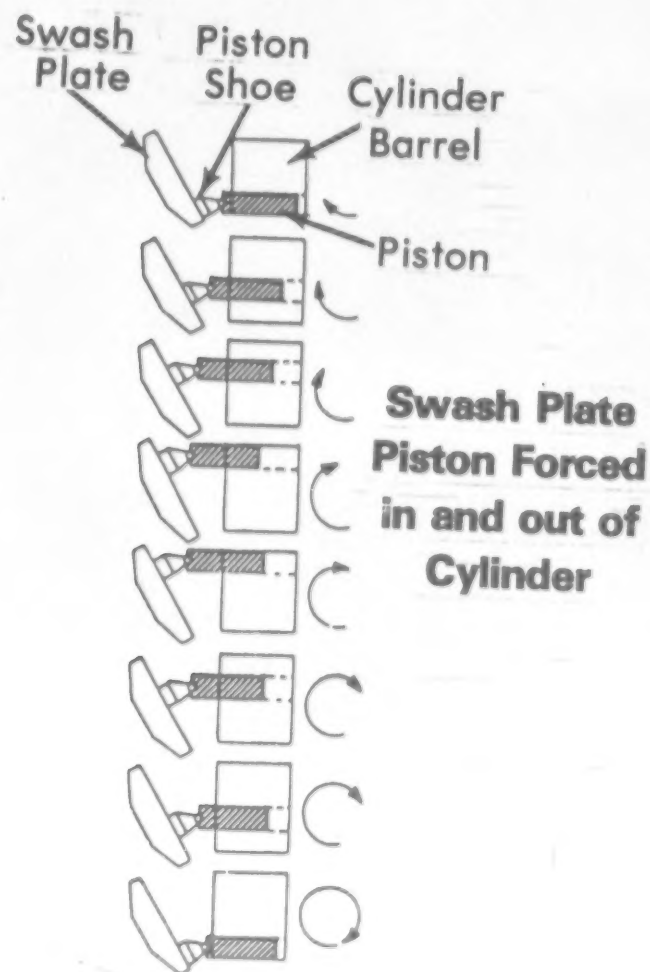
Construction and Operation of Axial Piston Pumps

243



**Piston Installation
in Circular Cylinder Block**

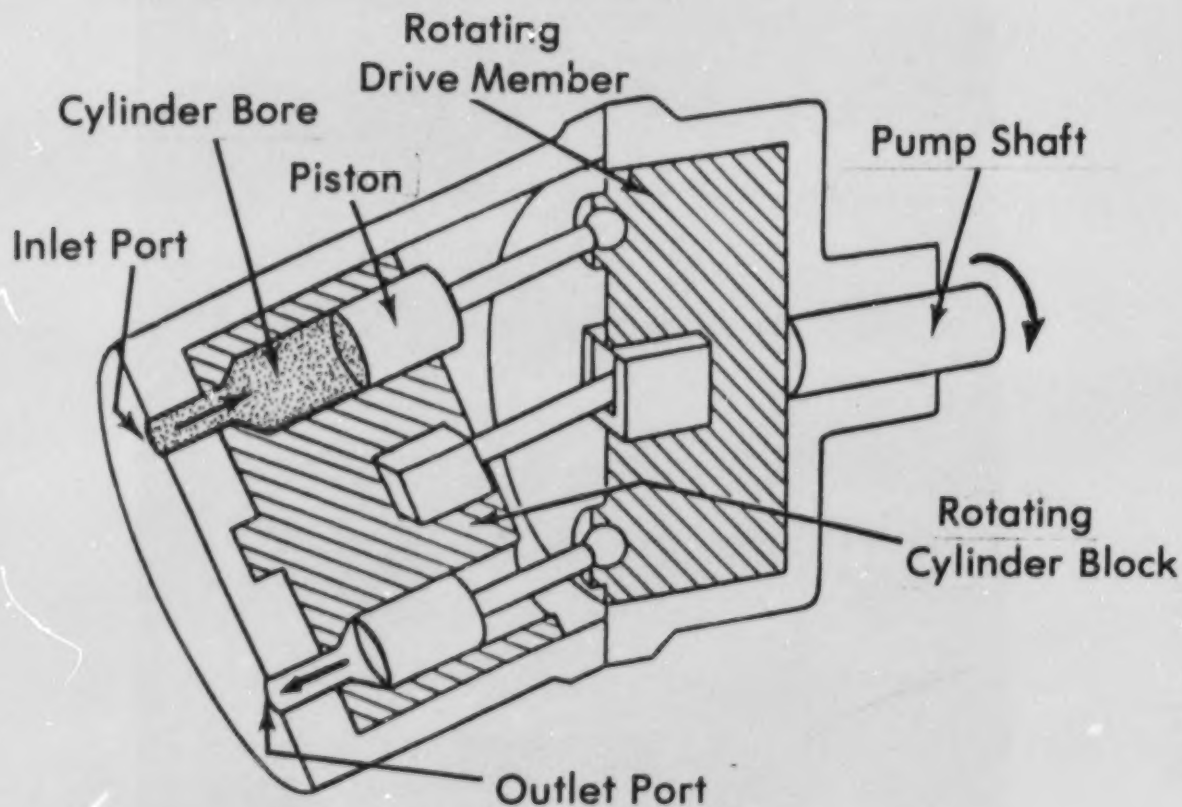
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192

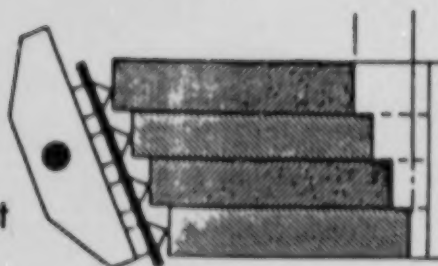
TM 4

Bent-Axis Axial Piston Pump Fixed Displacement



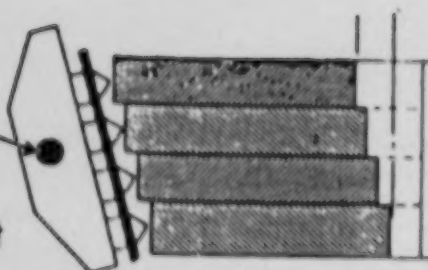
Operation of Variable Displacement Axial Piston Pump

Large Displacement

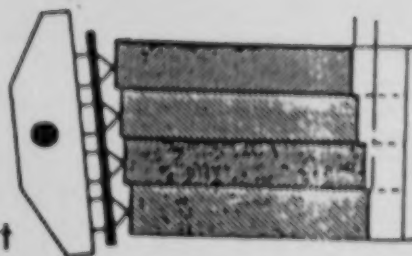


Trunnion

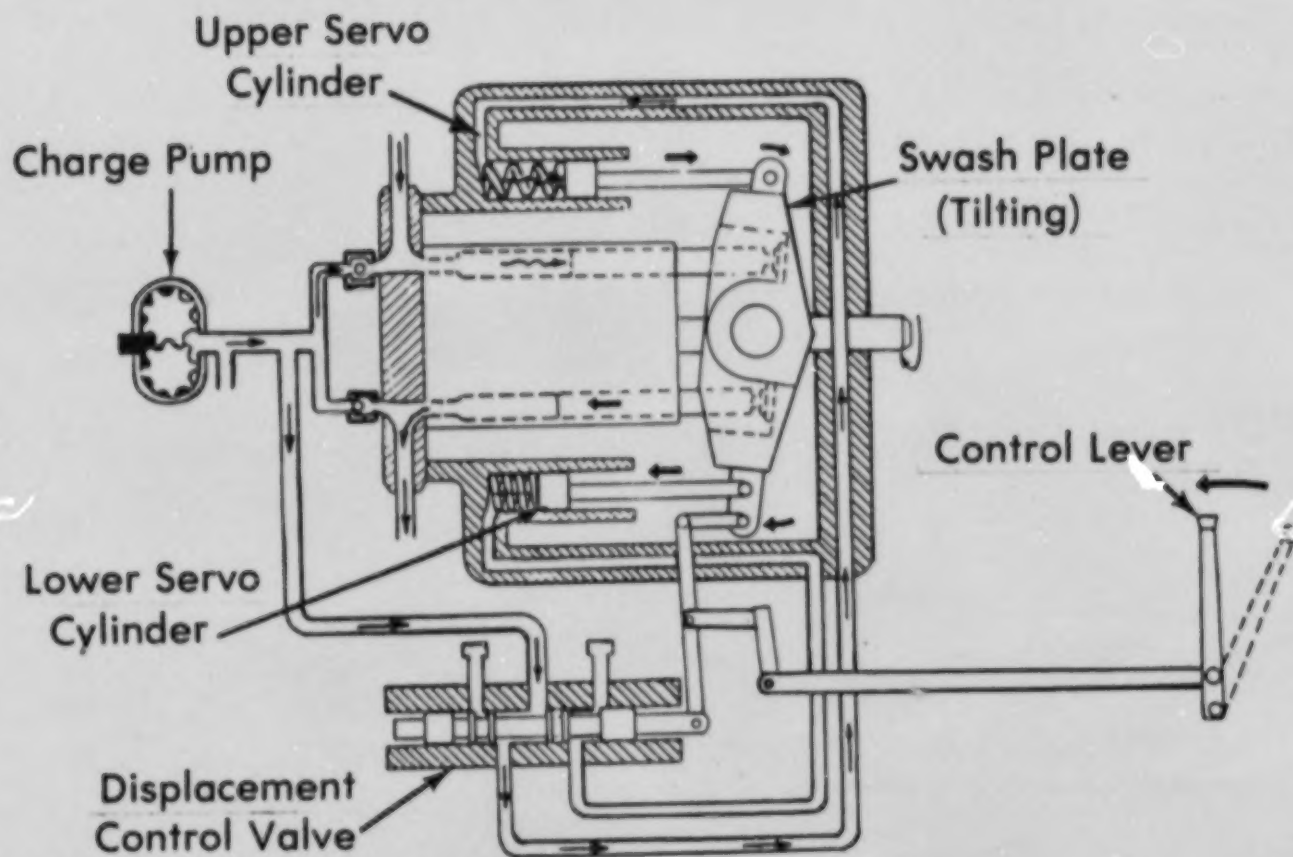
Medium Displacement



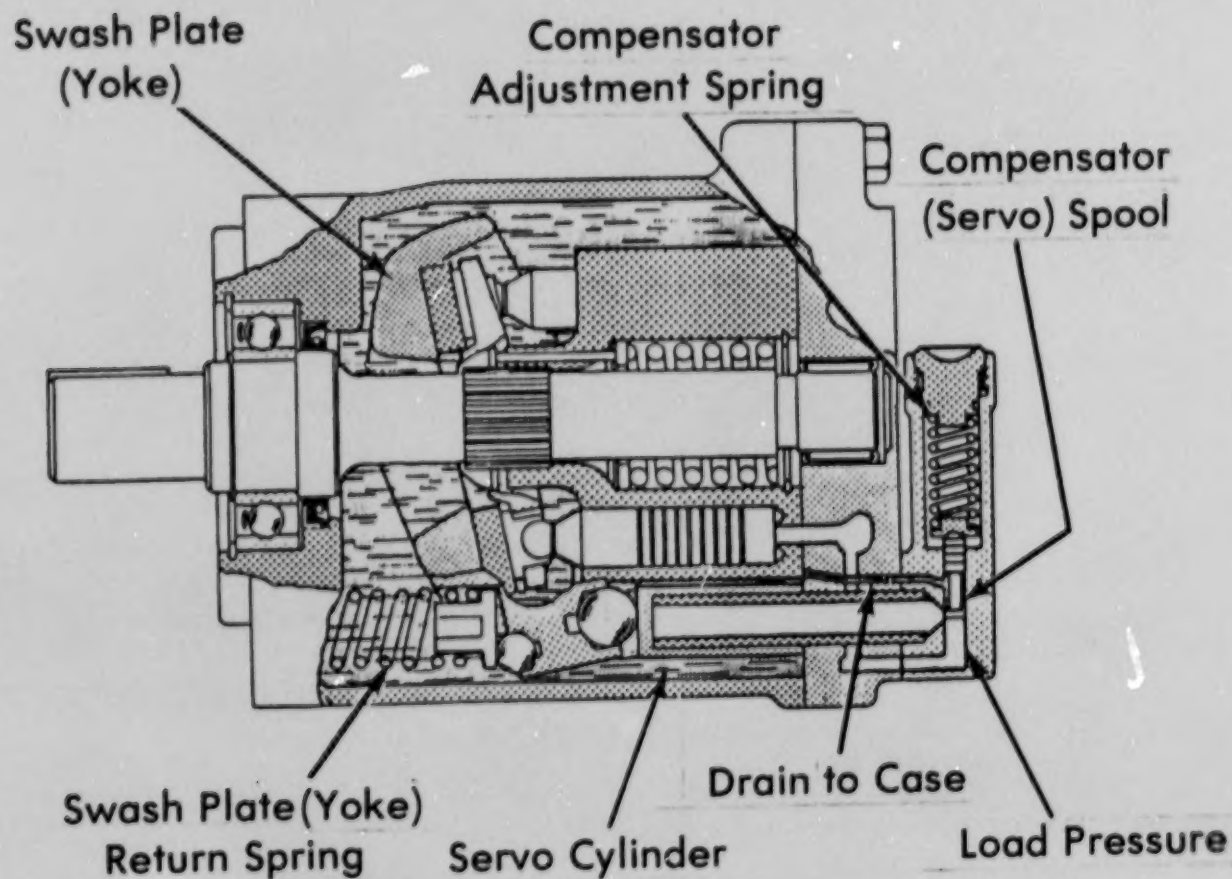
Small Displacement



Parts of a Servo-Controlled Variable Displacement Pump



Operation of Pressure Compensated Axial Piston Pumps



LESSON PLAN: 12

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

DEMONSTRATION LESSON: II-12

DISASSEMBLE, INSPECT, AND REASSEMBLE A GEAR PUMP
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Disassemble a gear pump.
2. Clean and inspect a gear pump.
3. Reassemble and test a gear pump for proper operation.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. Transparency master of parts of the pump being used in demonstration.
2. Service manual and materials for pump being used.

INFORMATIONAL ASSIGNMENT: (Student)

None

REFERENCES: (Instructor's Additional Information)

Service manual of pump used in demonstration.

INTRODUCTION:

Pumps, through proper servicing, can have a long life. To prevent unnecessary hydraulic systems problems the service worker should be alert to the signs of wear in a pump, such as aeration and foreign contaminants.

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LESSON PLAN: 12

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

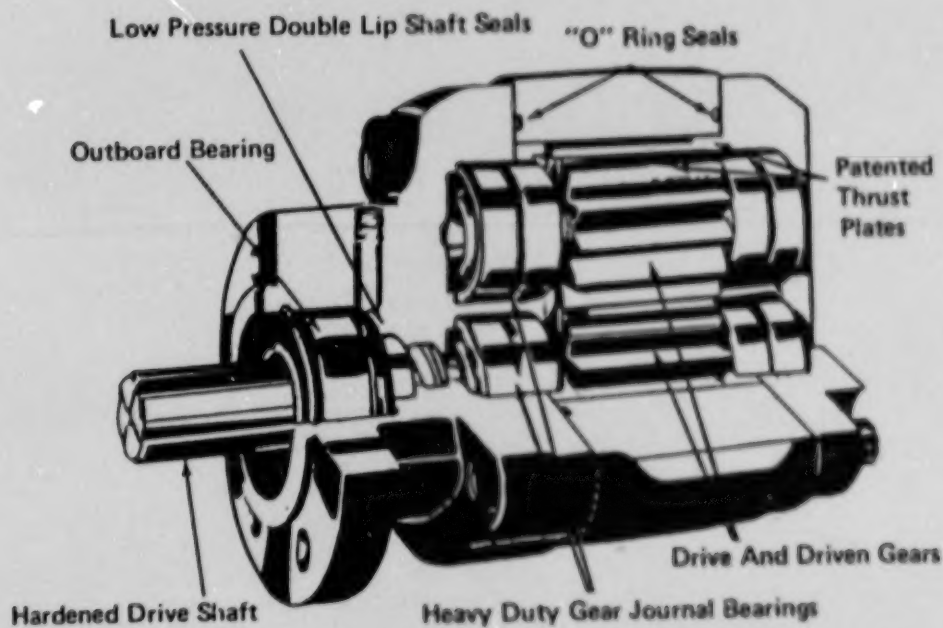
DEMONSTRATION: II-12

TOOLS, EQUIPMENT, AND MATERIALS:

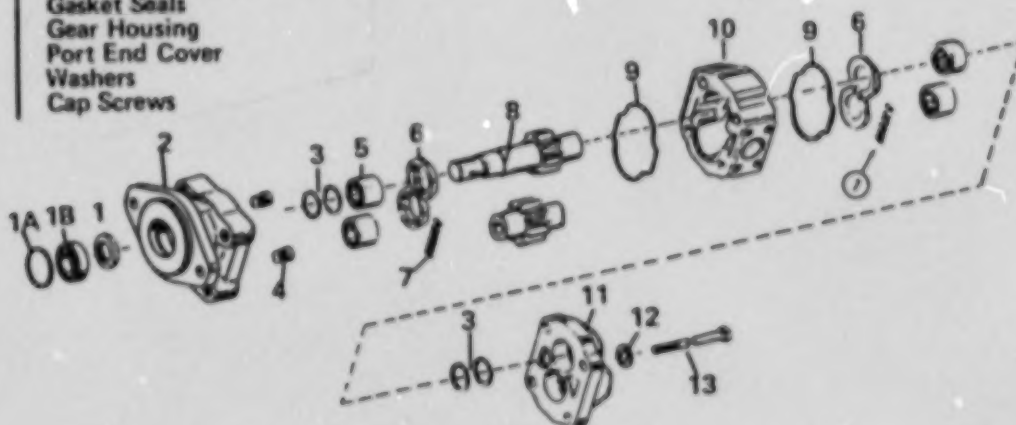
Gear pump
Service manual for pump (if available)
Hand tool set
Solvent
Lint-free shop towels
Safety glasses

STEPS OF PROCEDURE:

(NOTE: Figure 1 shows a cut-away drawing of a typical gear pump with an outboard bearing on the pump shaft. Figure 2 is an exploded view of this pump.)



Item	Description
1A	Snap Ring
1B	Outboard Bearing
1	Double Lip Seal
2	Shaft End Cover
3	Shaft Seals
4	Check Assemblies
5	Roller Bearings
6	Thrust Plates
7	Pocket Seals
8	Integral Shaft and Gear Set
9	Gasket Seals
10	Gear Housing
11	Port End Cover
12	Washers
13	Cap Screws



I. Disassemble

- A. Thoroughly clean the external surfaces of the pump with solvent.
- B. Dry the pump with shop towels.
- C. Place the pump on a clean surface for disassembly.
- D. Mark pump housings as to their location of inlet and outlets relative to the pump mountings.
- E. Remove the clip ring retainer on the outboard shaft bearing (if used).
- F. Remove the bearing.
- G. Remove the four cap screws which hold the pump housing together.
- H. Slowly remove the port (rear) end cover from the pump.
- I. Remove the two port-side roller bearings from the assembly.
- J. Remove the rear thrust plate.

(NOTE: Note the orientation of the plate.)

- J. Remove the gear housing from the pump.
- K. Carefully remove the two gears from the pump.
- L. Remove the shaft-side thrust plate noting orientation.
- M. Remove the two shaft-side roller bearings.
- N. Remove shaft seal.

II. Inspect

(NOTE: After completing each point in the inspection, check the appropriate box and briefly describe the condition of the components.)

Condition

- A. Examine the two thrust plates for excessive wear or scoring.
- B. Examine the gears for excessive wear and broken teeth.
- C. Examine the bearings for excessive wear and fractured bearings.
- D. Examine the shaft sealing surface for scoring.
- E. Examine the gear housing seals (usually O-rings) for nicks or breaks.
- F. Replace any part found to be defective.

III. Reassemble

(NOTE: Pre-lube parts during assembly.)

- A. Carefully install the shaft seal.
- B. Install the two shaft-side roller bearings.
- C. Install the shaft-side thrust plate.
- D. Install the two gears into the shaft end cover.
- E. Insure that the two seals on the gear housing are properly installed and then lower the gear housing around the two gears and align with the shaft end cover.

- F. Install the port-side thrust plate.
- G. Install the port-side roller bearings.
- H. Install the port-side end cover onto the assembly and carefully align.
- I. Install the four cap screws.
- J. Uniformly torque the screws to manufacturer's specifications by alternately applying torque to screws on opposite sides of the pump.
- K. Reinstall the shaft outboard bearing and clip ring.
- L. Fill pump with fluid as necessary before operation.

LESSON PLAN: 12

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-12

INTERACTION ITEMS:

1. Note proper installation, removal, and cleaning of seals covered in prior lesson.

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

1. Note pump trouble areas prior to demonstration lesson.
2. Point out trouble areas again during lesson.
3. Review any unforeseen problems and how you solved them.

LESSON PLAN: 12

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-12

EVALUATION ITEMS:

The student has satisfactorily completed the following steps of procedure:

- I. Disassembled.
- II. Cleaned and inspected.
- III. Reassembled and tested for proper operation.

Yes ____ No ____

Instructor's Signature
(Verifying Satisfactory Completion)

Date

LESSON PLAN: 13

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

DEMONSTRATION LESSON: II-13

DISASSEMBLE, CLEAN AND INSPECT, AND REASSEMBLE A PRESSURE
COMPENSATED VARIABLE DISPLACEMENT PUMP
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Disassemble.
2. Clean and inspect.
3. Reassemble, test, and adjust for proper operation.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. Transparency master of parts for pump being used in demonstration.
2. Service manual and material for pump being used.

INFORMATIONAL ASSIGNMENT: (Student)

None

REFERENCES: (Instructor's Additional Information)

Service and parts manuals of pump being used in the demonstration.

INTRODUCTION:

All pumps are not as simple as a gear pump. We now have the challenge of servicing a widely used pressure compensated variable displacement pump.

LESSON PLAN: 13

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-13

TOOLS, EQUIPMENT, AND MATERIALS:

Pressure compensated pump

(NOTE: This job sheet assumes that an in-line axial piston pump will be used.

The procedures are similar for other types of pressure compensated pumps.)

Service manual for pump

Hand tool set

Solvent

Lint free shop towels

Safety glasses

STEPS OF PROCEDURE:

(NOTE: The procedures here assume a pressure compensated in-line axial piston pump. A cut-away view of such a pump is shown in Figure 1. An exploded view of this pump is shown in Figure 2.)

FIGURE 1

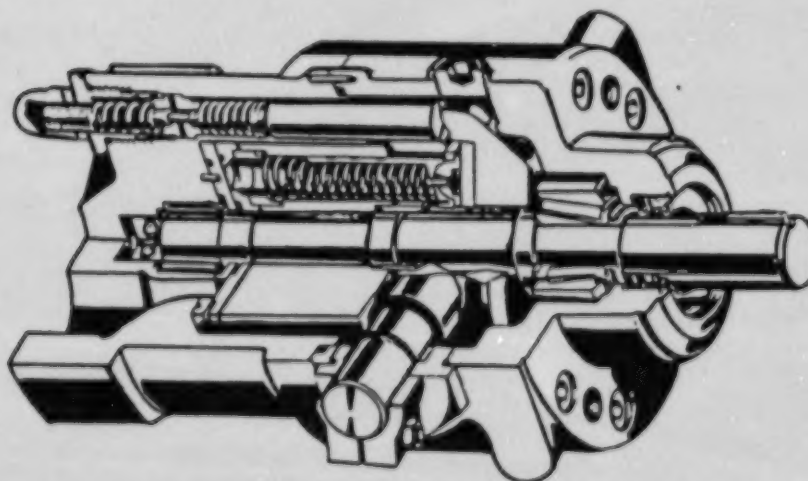
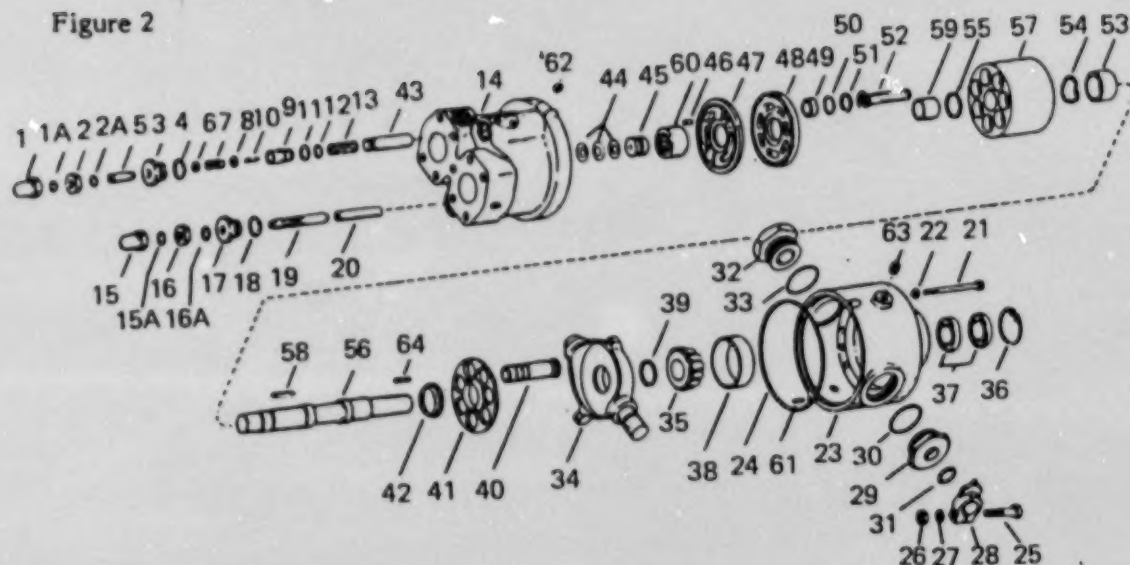


Figure 2

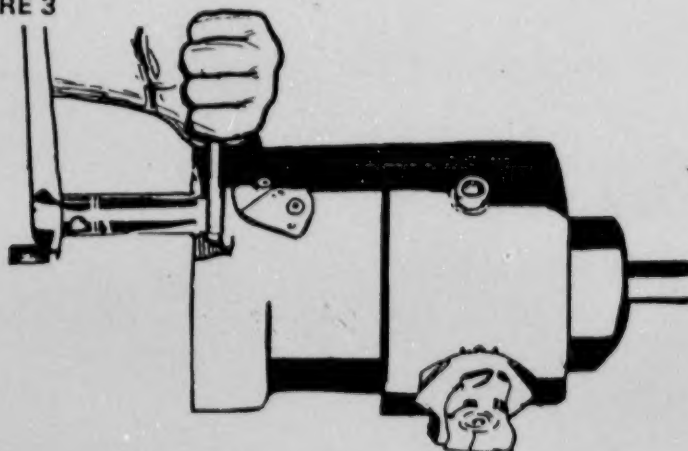


No.	Description	Qty.	No.	Description	Qty.	No.	Description	Qty.
1	Acorn nut	1	20	Control piston	1	42	Ball bushing	1
1A	Packing, preformed	1	21	Cap screw	8	43	Port end cover	1
2	Jam nut	1	22	Washer	8	44	Spring	3
2A	Packing, preformed	1	23	Drive cover	1	45	Bearing	1
3	Adjustment plug	1	24	Preformed packing	1	46	Dowel	1
4	Preformed packing	1	25	Cap screw	1	47	Fixed port plate	1
5	Adjustment screw	1	26	Nut	1	48	Rotating port plate	1
6	Spring seat	1	27	Lockwasher	1	49	Cylinder seal	7
7	Compensator Spring	1	28	Indicator	1	50	Preformed packing	7
8	Spring seat	1	29	Thru trunnion nut	1	51	Washer	7
9	Compensator shell	1	30	Preformed packing	1	52	Spring	7
10	Compensator piston	1	31	Preformed packing	1	53	Spring sleeve	1
11	Quad ring	1	32	Blind trunnion nut	1	54	Wave washer	3
12	Quad ring	1	33	Preformed packing	1	55	Snapping	1
13	Starting spring	1	34	Reaction swivel assy	1	56	Drive shaft	1
14	Control piston	1	35	Bearing	1	57	Rotor	1
15	Acorn nut	1	36	Snapping	1	58	Key	1
15A	Packing, preformed	1	37	Seal	2	59	Bearing race	1
16	Jam nut	1	38	Bearing cup	1	60	Bearing	1
16A	Packing, preformed	1	39	Thrust washer	1	61	Case dowel	1
17	Adjustment plug	1	40	Piston assembly	7	62	Pipe plug	1
18	Preformed packing	1	41	Holddown plate	1	63	Pipe plug	1
19	Adjustment screw	1				64	Key	1

1. Disassemble

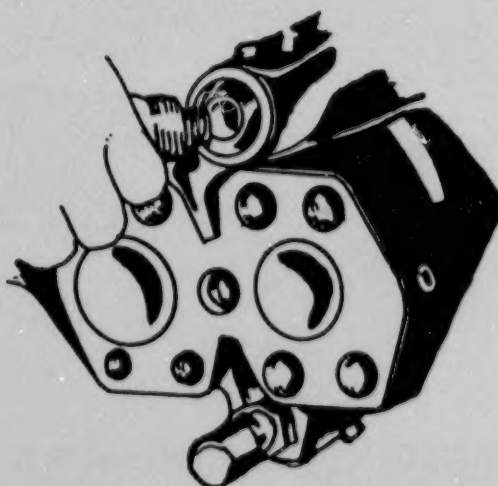
- A. Clean the external surfaces of the pump using solvent to remove all dirt and grime.
- B. Dry pump with shop towels.
- C. Loosen the jam nut and unscrew the compensator adjustment screw (Figure 3).

FIGURE 3



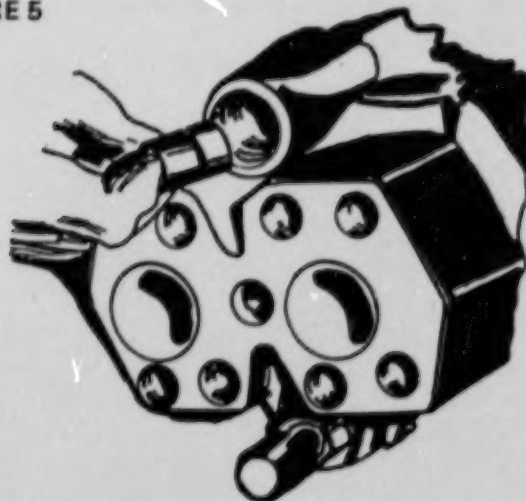
- D. Remove the compensator spring seat and compensator spring (Figure 4).

FIGURE 4



- E. Remove the compensator spool (Figure 5).

FIGURE 5



- F. Remove the compensator piston and spring (Figure 6).

FIGURE 6



- G. Remove the retaining nut for the compensator piston on the other side of the pump.
- H. Remove the spring and piston.

- I. Unscrew the cap screws that hold the pump housing together (Figure 7).

(NOTE: Be careful to lift the cover straight up. Be especially careful to insure that the pistons are free of the swash plate.) (Figure 8)

FIGURE 7

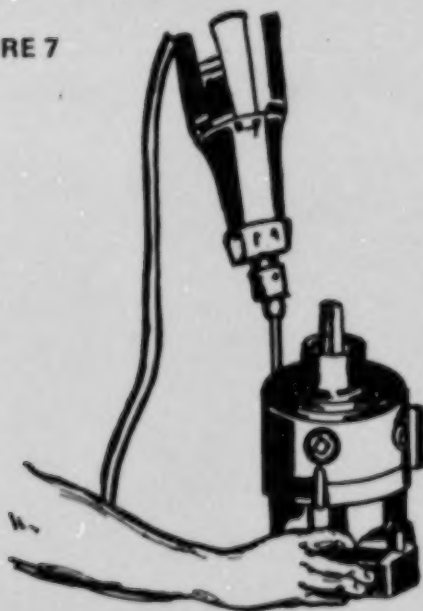
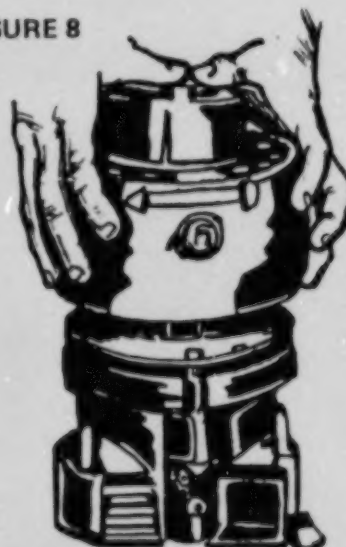


FIGURE 8



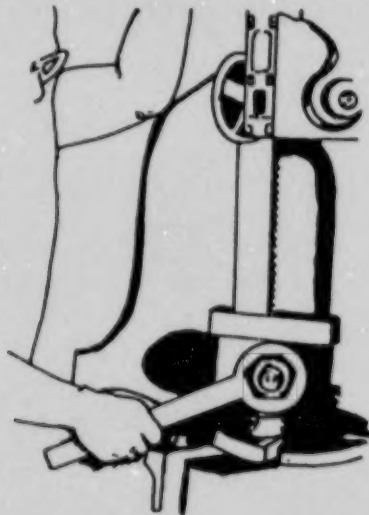
- J. Carefully remove the drive end cover from the port end cover (Figure 9).

FIGURE 9



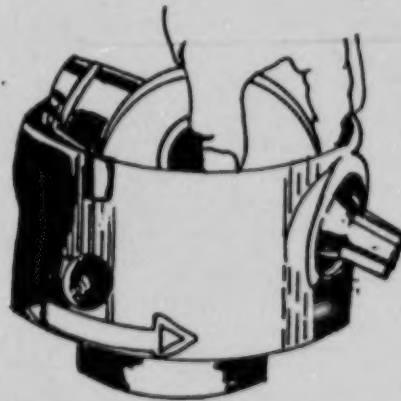
- K. Remove the trunnion nut from the assembly (Figure 10).

FIGURE 10



- L. Remove the swash plate from the drive cover (Figure 11).

FIGURE 11



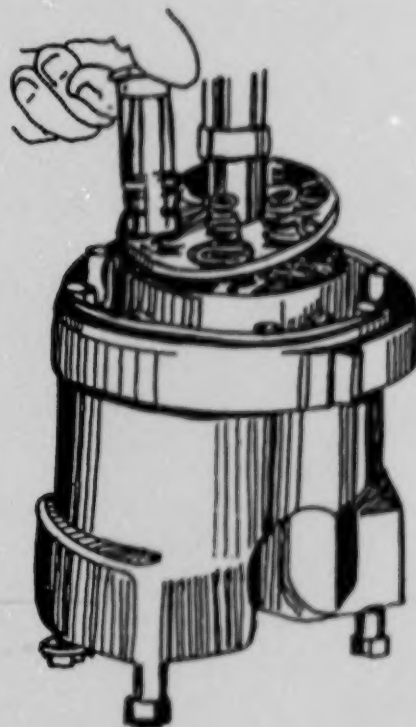
- M. Remove the snap ring, seals, and bearings from the shaft cover (Figure 12).

FIGURE 12



- N. Remove the pistons from the assembly (Figure 13).

FIGURE 13



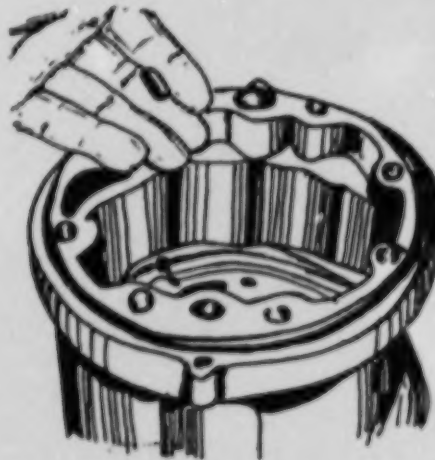
- O. Remove the port end cover from the barrel and shaft assembly (Figure 14).

FIGURE 14



- P. Remove the port plate from the port end cover (Figure 15).

FIGURE 15



II. Inspect

(NOTE: After completing each point in the inspection, check the appropriate box and briefly describe the condition of the components.)

	✓	Condition
A. Inspect the pistons and piston bore for scoring or excessive wear.	☐	
B. Inspect the piston shoe for excessive wear.	☐	
C. Examine the swash plate for excessive wear.	☐	
D. Inspect the shaft seat for scoring and excessive wear.	☐	
E. Examine the compensator piston.	☐	
F. Examine the compensator spool for wear.	☐	
G. Inspect the compensator fluid passages for blockage and clean if necessary.	☐	
H. Examine the port plate for wear or cracking.	☐	

III. Reassemble

- A. Install the port plate into the port end housing.
- B. Place the cylinder barrel and shaft assembly into the port end housing.
- C. Install the pistons into the assembly.
- D. Install the bearing, seal, and seal-retainer ring into the shaft end cover.
- E. Install the swash plate into the shaft end cover.
- F. Install the trunnion nut to secure the swash plate.
- G. With the port end cover lying on a flat surface with the ports down, carefully lower the shaft end cover onto the assembly.
- H. Make sure that the piston shoes properly contact the swash plate.
- I. Install the cap screws to secure the two halves of the pump assembly.
- J. Torque the screws to manufacturer's recommended specifications by tightening screws on opposite sides of the pump in sequence.
- K. Install the lower piston with spring and tighten screw cap.
- L. Install the upper piston with spring, compensator spool, spool spring, and adjustment screw.
- M. Tighten adjustment screw only partially into the pump.

LESSON PLAN: 13

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-13

INTERACTION ITEMS: (Review Items)

1. Note proper handling of seal surfaces.
2. Note points at which the fluid forms its own seal between parts.

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

None

LESSON PLAN: 13

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION: II-13

EVALUATION ITEMS:

The student has satisfactorily completed the following steps of procedure:

- I. Disassembled.
- II. Cleaned and inspected.
- III. Reassembled, tested, and adjusted for proper operation as noted in the service materials.

Yes ____ No ____

Instructor's Signature
(Verifying Satisfactory Completion)

Date

LESSON PLAN: 14

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

INFORMATION TOPIC: II-14

INTRODUCTION TO HYDRAULIC VALVES
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Match terms related to valves with the correct definitions.
2. Name three categories of valves.
3. Name three types of pressure control valves.
4. Name the types of pressure relief valves when given a description of their operations.
5. Select true statements concerning the operation of a pressure reducing valve.
6. List three types of flow control valves.
7. Select true statements concerning the operation of a needle valve as a flow control device.
8. Select true statements concerning the operation of a pressure compensated flow control valve.
9. Select true statements concerning the operation of a priority flow divider.
10. Select true statements concerning the operation of a proportional flow divider.
11. Identify types of directional control valves.
12. Distinguish between the operation of a check valve and a spool direction control valve.
13. Discuss the flow paths in a directional control valve controlling a cylinder.
14. Distinguish between open center and closed center systems.
15. Select types of actuators for directional control valves.
16. Identify symbols for hydraulic valves.
17. List four other valves found in some hydraulic systems.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Operation of a Pressure Relief Valve
2. TM 2: Types of Pressure Relief Valves
3. TM 3: Operation of a Pressure Reducing Valve
4. TM 4: Operation of Flow Control Valves
5. TM 5: Types of Directional Control Valves
6. TM 6: Operation of Directional Control Valves

7. TM 7: Open and Closed Center Spool Valves (In Neutral)
8. TM 8: Symbols for Hydraulic Valves
9. TM 9: Tandem/Hydraulic Motor Spool

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979, Chap. 3.

REFERENCES: (Instructor's Additional Information)

Fluid Power I. Cleveland, OH: Parker-Hannifin Corporation, 1975.

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979.

INTRODUCTION:

Valves are the controls of the hydraulic system. They regulate the pressure, direction, and volume of oil flow in the hydraulic circuit.

LESSON PLAN: 14

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-14

OUTLINE: (Key Points)

I. Terms and definitions

- A. **Valve** - a device which controls fluid flow directions, pressure, or flow rate
- B. **Pressure control valve** - a valve whose function is to control pressure
- C. **Flow control valve** - a valve whose function is to control flow rate
- D. **Directional control valve** - a valve whose primary function is to direct or prevent flow through selected passages
- E. **Relief valve** - a valve which is used to limit the maximum pressure in a hydraulic system
- F. **Poppet** - that part of certain valves which prevents flow when it closes against a seat
- G. **Spool** - a term loosely applied to almost any moving cylindrically shaped part of a hydraulic component which moves to direct flow through the component
- H. **Pilot valve** - an auxiliary valve used to control the operation of another valve; the controlling stage of a 2-stage valve
- I. **Feathering** - the operation of moving a valve through partial travel in order to get reduced flow rate

II. Categories of valves

- A. Pressure control
- B. Flow control
- C. Directional control

III. Types of pressure control valves

- A. Relief valve

1. Simple
2. Compound or pilot operated

B. Pressure reducing

IV. Types and operation of pressure relief valves (TM 1)

A. Simple (TM 2)

1. A spring holds a poppet against a seat.
2. When the pressure in the system is large enough to overcome the spring force, the poppet moves off of the seat to allow fluid flow to the bypass.
3. The spring tension is set so that the poppet opens to divert sufficient flow from the rest of the system and limit the pressure to a specified value.

(NOTE: It is important to remember that pressure and flow in a hydraulic system are directly related.)

B. Compound (TM 2)

1. A spring holds the main stage spool so that the discharge port is normally blocked.
2. A small amount of fluid flows past the main stage spool through a passage to another valve which is also part of the relief valve.

(NOTE: This valve is known as the pilot valve.)

3. The pressure of the fluid emitted to the pilot valve creates a force on the pilot valve poppet.
4. If this force is greater than the spring force, then the poppet moves off its seat, allowing a small amount of fluid to flow out the drain.
5. The pressure drop resulting from flow past the pilot valve poppet is experienced on the back side of the main stage spool and the spool shifts.
6. This pressure force on the spool plus the main stage spring force must be overcome by the system pressure on the front side of the main stage spool before this spool moves off its seat to allow flow to the discharge.

(NOTE: Remember that force = pressure x area.)

7. In operation, the tension on the pilot stage spring is adjusted so that the main stage spool opens at some specified pressure.

(NOTE: Although the compound relief valve is more complex than a simple relief valve, it is often used because it does a better job of limiting the system pressure to a specified value.)

C. Remote pilot operated

1. The operation is similar to a compound relief valve except the pilot stage is not part of the relief valve package.
2. A separate pilot valve in a remote location is used to adjust relief valve pressure.

V. Operation of a pressure reducing valve (TM 3)

(NOTE: This is the only pressure control valve that is normally open.)

- A. A pressure reducing valve controls the pressure in a secondary circuit to a specific value. When the pressure in this circuit is low, the spool is fully open.
- B. The secondary circuit pressure acts on one side of the spool, and when this pressure is great enough to move the spool against the spring, the flow passage from the main to the secondary circuit is restricted.
- C. This operation will regulate the pressure in the secondary circuit as long as the main circuit pressure is greater than the desired secondary circuit pressure.
- D. The secondary circuit pressure can be adjusted by adjusting the spring tension.

(NOTE: Only constant reduced pressure valves have been discussed. Some pressure reducing valves provide a fixed amount of pressure reduction (such as 500 psi) across a valve. The operation of this valve is similar, except secondary circuit pressure is applied to both sides of the spool.)

VI. Types of flow control valves (available with or without reverse flow checks)

A. Needle valve

(NOTE: This is also called a simple restrictor.)

- B. Compensated flow control valve
- C. Flow divider

VII. Operation of a needle valve as a flow control device (TM 4)

- A. A needle valve serves as an adjustable means of regulating the flow to a secondary circuit (such as a motor or a cylinder) by restricting the fluid flow.
- B. As the knob on the needle valve is turned, the flow orifice changes.
- C. With the knob turned to its extreme position the needle closes onto a seat restricting the fluid flow.

(NOTE: A needle valve is considered an uncompensated flow control because flow will increase if the inlet pressure increases.)

VIII. Operation of a pressure compensated flow control valve (TM 4)

- A. Flow through a fixed orifice in the inlet causes a pressure drop.
- B. The full inlet pressure is applied to the inlet side and a reduced pressure is applied to the spring side of the spool.
- C. If the force created by the pressure differences is greater than the spring force, the valve spool moves to close the outlet orifice and thus reduces the flow rate.
- D. The system functions to maintain a constant pressure drop across the inlet orifice. If this pressure drop is controlled, the flow will be controlled.
- E. The flow may be varied by varying the spring tension.

IX. Operation of a priority flow divider (TM 4)

- A. A priority flow divider functions to supply a regulated flow to the priority output, and the remaining flow is routed to the secondary circuit.
- B. As the flow divider spool slides in its bore, one outlet is opened wider when the other is closed off.
- C. Fluid from the inlet is metered through an orifice in the spool, causing a pressure drop which tends to displace the spool to close off the priority outlet, and this displacement is resisted by the spring.
- D. The spool will position to maintain a constant pressure drop across the spool orifice and thus a constant flow to the priority outlet.

- E. The secondary outlet will be opened to receive the remaining flow that is available.

(NOTE: A priority flow divider is used in circuits where flow must be maintained to some part of the circuit. A common example is when a single pump is used to supply steering at a constant flow rate, say 2 GPM. Any remaining flow is then available to the auxiliary circuits.)

X. Operation of a proportional flow divider (TM 4)

- A. A proportional flow divider is used to divide the flow into two circuits.
- B. Fluid from the inlet flows through two orifices (one on each side of the spool) causing a pressure drop across the two orifices; the resulting pressure is applied to each side of the spool.
- C. If the pressure drop across the two orifices is not equal, the spool shifts and changes the restriction at the outlet orifice.
- D. The valve functions to maintain equal pressure drop across the inlet orifices.

(NOTE: The ratio of the flow from the two outlets is set by the size of the two inlet orifices. Equal orifice sizes result in equal flow rates.)

XI. Types of directional control valves (TM 5)

- A. Check valve
- B. Rotary valve
- C. Spool valve

XII. Operation of a check valve and a spool direction control valve (TM 6)

- A. Check valve
 - 1. Only allows fluid to flow in one direction, from inlet to outlet.
 - 2. When pressure is applied to the inlet, it causes the valve to open against the spring allowing flow to pass.
 - 3. When pressure is applied to the outlet side of the check valve, the valve is held firmly against its seat thus blocking fluid flow in this direction.
- B. Spool direction control valve
 - 1. A directional control valve serves to "direct" the fluid from a pump to an actuator such as a motor or cylinder.

2. Lands on spool are used to open or close openings to passages in the valve body.

XIII. Flow paths in a directional control valve controlling a cylinder (TM 6)

A. Valve shifted to extend cylinder

1. The handle is moved to the left and the lands open flow passages from the pump to the head side of the cylinder.
2. A flow passage from the rod side of the cylinder is opened to route this flow to the reservoir.

B. Valve shifted to retract the cylinder

1. The valve is moved to the right and lands open flow passages from the pump to the rod side of the cylinder.
2. A flow passage from the head side of the cylinder is opened to route this flow to the reservoir.

XIV. Fluid flow in directional control valves in the neutral position (TM 7)

A. Open center - all ports connected

1. These valves have lands which direct the pump to the reservoir when the valve is in the neutral position.
2. The lands may be positioned on the spool to block flow from both sides of the cylinder (TM 8) or allow flow to pass from one side to the other side of the cylinder.

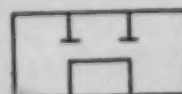
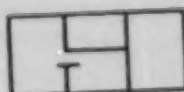
(NOTE: These are called open center valves, and are used with fixed displacement pumps (constant flow pumps). Such systems are called open center systems.)

B. Closed center - all ports blocked

1. The lands are positioned on the spool to block flow from the pump when the valve is in the neutral position.
2. The lands may be positioned on the spool to block flow from both sides of the cylinder, or allow flow to pass from one side to the other side of the cylinder.

C. Tandem-center - cylinder ports blocked

D. Motor spool



XV. Actuators for directional control valves

- A. Hand lever
- B. Electrical solenoid

(NOTE: This allows an electric signal to shift the valve to either extreme.)

- C. Servo valve

(NOTE: This allows an electric signal to shift the valve to various intermediate positions.)

- D. Proportional valve
- E. Pilot operated

(NOTE: This allows hydraulic pressure to shift the valve.)

- F. Method of holding position
 - 1. Detent
 - 2. Pressure
 - 3. Spring
 - 4. Full floating

XVI. Symbols for hydraulic valves (TM 9)

- A. Pressure control

- 1. Adjustable relief valve



- 2. Adjustable pressure reducing valve



- B. Flow control

- 1. Adjustable restrictor

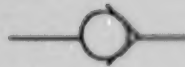


2. Adjustable pressure compensated flow control



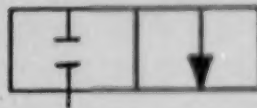
C. Directional control

1. Check valve

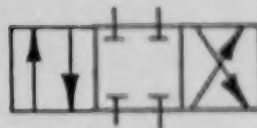


2. Spool valves

a. 2 way



b. 3 way



c. 4 way



XVII. Other valves found in some hydraulic systems

(NOTE: Instructor will need to supplement this material with additional information on these valves.)

- A. Unloading valves
- B. Counter balance valves
- C. Flow control with a reverse check valve
- D. Over-center

LESSON PLAN: 14

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-14

INTERACTION ITEMS: (Review Items)

Discuss these statements:

1. You can have pressure without flow but you cannot have flow without pressure.
2. Hydraulic valves control but do not change hydraulic energy. (Pumps and motors change forms of energy.)

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

Obtain examples of as many types of controls as possible. Pass them around so students can examine them.

LESSON PLAN: 14

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-14

EVALAUTION ITEMS:

1. Match the terms on the right with the correct definitions.

- | | | |
|--------|---|------------------------------|
| ___ a. | A valve whose function is to direct or prevent flow through selected passages | 1. Poppet |
| ___ b. | A term loosely applied to almost any moving cylindrically shaped part of a hydraulic component which moves to direct flow through the component | 2. Pressure control valve |
| ___ c. | A valve whose function is to control pressure | 3. Spool |
| ___ d. | An auxiliary valve used to control the operation of another valve; the controlling stage of a 2-stage valve | 4. Directional control valve |
| ___ e. | A device which controls fluid flow direction, pressure, or flow rate | 5. Feathering |
| ___ f. | A valve whose function is to control flow rate | 6. Flow control valve |
| ___ g. | That part of certain valves which prevents flow when it closes against a seat | 7. Relief valve |
| ___ h. | A valve which is used to limit the maximum pressure in a hydraulic system | 8. Pilot |
| ___ i. | The operation of moving a valve through partial travel in order to get reduced flow rate | 9. Valve |

2. Name three categories of valves.

a.

b.

c.

3. Name two types of pressure control valves.

a.

b.

4. Name the types of pressure relief valves for the following operations:

a.

1. The operation is similar to a compound relief valve except the pilot stage is not part of the relief valve package.
2. A separate pilot valve in a remote location is used to adjust relief valve pressure.

b.

1. A spring holds a poppet against a seat.
2. When the pressure in the system is large enough to overcome the spring force, the poppet moves off of the seat to allow fluid flow to the bypass.
3. The spring tension is set so that the poppet opens to divert sufficient flow from the rest of the system and limit the pressure to a specified value.

c.

1. A spring holds the main stage spool so that the discharge port is normally blocked.
2. A small amount of fluid flows past the main stage spool through a passage to another valve which is also part of the relief valve.
3. The pressure of the fluid emitted to the pilot valve creates a force on the pilot valve poppet.

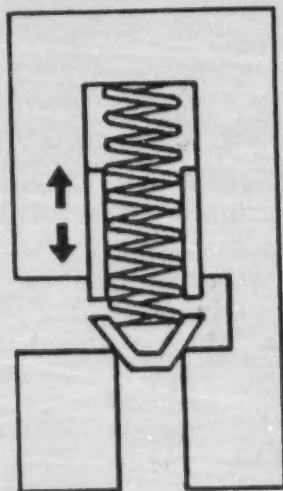
4. If this force is greater than the spring force, the poppet moves off its seat, allowing a small amount of fluid to flow out the drain.
 5. The pressure resulting from flow past the pilot valve poppet is applied to the back side of the main stage spool.
 6. This pressure force on the spool plus the main stage spring force must be overcome by the system pressure on the front side of the main stage spool before this spool moves off its seat to allow flow to the discharge.
 7. In operation, the tension on the pilot stage spring is adjusted so that the main stage spool opens at some specified pressure.
5. Select true statements concerning the operation of a pressure reducing valve by placing an "X" in the appropriate blanks.
- ☐ a. A pressure reducing valve controls the pressure in a secondary circuit to a specified value. When the pressure in this circuit is low, the spool is fully open.
 - ☐ b. The secondary circuit pressure acts on both sides of the spool, and when this pressure is great enough to move the spool against the spring the flow passage from the main to the secondary circuit is completely open.
 - ☐ c. The secondary circuit pressure can be adjusted by adjusting the spring tension.
6. List three types of flow control valves.
- a.
 - b.
 - c.
7. Select true statements concerning the operation of a needle valve as a flow control device by placing an "X" in the appropriate blanks.
- ☐ a. A needle valve serves as an adjustable means of regulating the flow to a secondary circuit by restricting the fluid flow.
 - ☐ b. As the knob on the needle valve is turned, a needle is lowered into the fluid stream.
 - ☐ c. With the knob turned to its extreme position the needle closes onto a seat, restricting the fluid flow.

8. Select true statements concerning the operation of a pressure compensated flow control valve by placing an "X" in the appropriate blanks.
- ☐ a. Flow through a fixed orifice in the inlet causes a pressure rise.
 - ☐ b. The full inlet pressure is applied to the inlet side and a reduced pressure is applied to the spring side of the spool.
 - ☐ c. If the force created by the pressure differences is greater than the spring force, the valve spool moves to close the outlet orifice and thus reduces the flow rate.
 - ☐ d. The system functions to maintain a constant pressure rise across the inlet orifice. If this pressure rise is controlled, the flow will be controlled.
 - ☐ e. The flow may be varied by varying the spring tension.
9. Select true statements concerning the operation of a priority flow divider by placing an "X" in the appropriate blanks.
- ☐ a. A priority flow divider functions to supply a regulated flow to the priority output, and the remaining flow is routed to the secondary circuit.
 - ☐ b. As the flow divider spool slides in its bore, both outlets are opened.
 - ☐ c. Fluid from the inlet is metered through an orifice in the spool, causing a pressure drop which tends to displace the spool to close off the priority outlet, and this displacement is resisted by the spring.
 - ☐ d. The spool will position to maintain a constant pressure drop across the spool orifice and thus a constant flow to the priority outlet.
 - ☐ e. The primary outlet will be opened to receive the remaining flow that is available.
10. Select true statements concerning the operation of a proportional flow divider by placing an "X" in the appropriate blanks.
- ☐ a. A proportional flow divider is used to divide the flow into three circuits.
 - ☐ b. Fluid from the inlet flows through two orifices causing a pressure drop across the two orifices; the resulting pressure is applied to each side of the pool.
 - ☐ c. If the pressure drop across the two orifices is not equal, the spool shifts and changes the restriction at the outlet orifice.

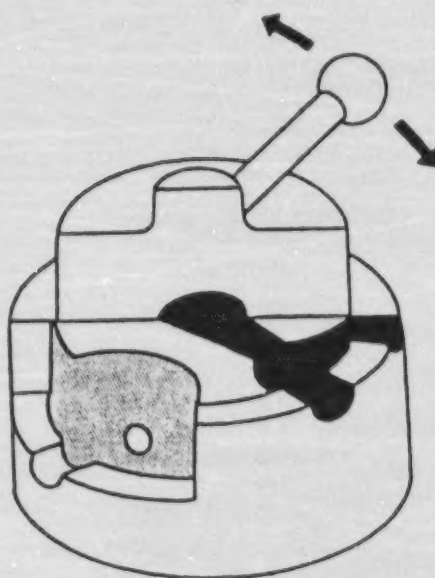
- ___ d. The valve functions so that inlet orifices have an unequal pressure drop across them.

11. Identify the types of directional control valves.

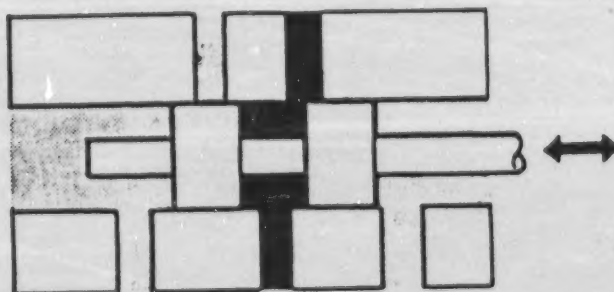
a.



b.



c.



12. Distinguish between the operation of a check valve and a spool direction control valve by placing an "X" next to the descriptions which apply to the operation of a check valve.

- ___ a. Serves to "direct" the fluid from a pump to an actuator such as a motor or cylinder.
- ___ b. When pressure is applied to the inlet, it causes the valve to open against the spring allowing flow to pass.
- ___ c. Lands on spool are used to open or close openings to passages in the valve body.
- ___ e. When pressure is applied to the outlet side, the valve is held firmly against its seat, thus blocking fluid flow in this direction.

13. Discuss the flow paths in a directional control valve controlling a cylinder.

- a. Valve shifted to extend cylinder

- b. Valve shifted to retract the cylinder

14. Distinguish between open-, closed-, and tandem-center systems by placing an "O" next to the descriptions which apply to open-center systems, a "C" next to descriptions which apply to closed-center systems, and "T" next to descriptions which apply to tandem-center systems.

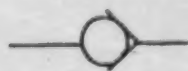
(NOTE: Some descriptions may apply more than one system.)

- ___ a. The lands may be positioned on the spool to block the flow from both sides of the cylinder, or to allow flow to pass from one side to the other side of the cylinder.
- ___ b. The lands are positioned on the spool to block flow from the pump when the valve is in the neutral position.
- ___ c. These valves have lands which direct the pump to the reservoir when the valve is in the neutral position.
- ___ d. The lands are positioned on the spool to block flow from both sides of the cylinder and allow flow from the pump to return to the reservoir when the valve is in the neutral position.

15. Select types of actuators for directional control valves by placing an "X" in the appropriate blanks.

- ___ a. Hand lever
- ___ b. Electrical solenoid
- ___ c. Relief valve
- ___ d. Servo valve
- ___ e. Open center valve
- ___ f. Pilot operated
- ___ g. Proportional valves

16. Identify the symbols for hydraulic valves



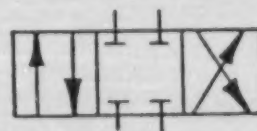
a. _____



b. _____



c. _____



d. _____



e. _____



f. _____



g. _____

17. List four other types of valves found in some hydraulic systems.

a.

b.

c.

d.

LESSON PLAN: 14

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

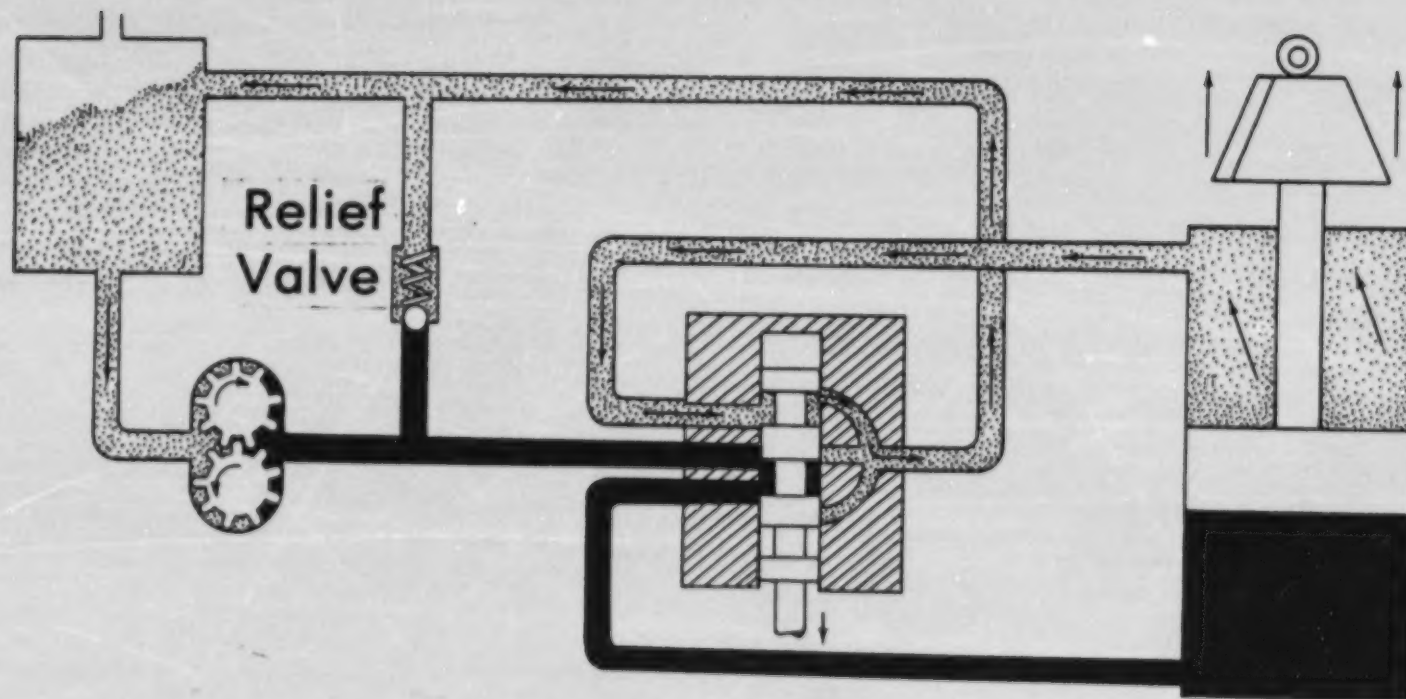
INFORMATION TOPIC: II-14

ANSWERS TO EVALUATION ITEMS:

1. a. 4 e. 9
 b. 3 f. 6
 c. 2 g. 1
 d. 8 h. 7
 i. 5
2. a. Pressure control
 b. Flow control
 c. Directional control
3. a. Relief valve
 b. Pressure reducing
4. a. Pilot operated
 b. Simple
 c. Compound
5. a, c
6. a. Needle valve
 b. Compensated flow control valve
 c. Flow divider
7. a, b, c
8. b, c, e
9. a, c, d
10. b, c
11. a. Check valve
 b. Rotary valve
 c. Spool valve
12. b, d, e

13. Discussion should include:
- a. Valve shifted to extend cylinder
 - 1) The handle is moved to the left and the lands open flow passages from the pump to the head side of the cylinder.
 - 2) A flow passage from the rod side of the cylinder is opened to route this flow to the reservoir.
 - b. Valve shifted to retract the cylinder
 - 1) The valve is moved to the right and lands open flow passages from the pump to the rod side of the cylinder.
 - 2) A flow passage from the head side of the cylinder is opened to route this flow to the reservoir.
14. a. O, C
b. C
c. O
d. T
15. a, b, d, f, g
16. a. Check valve
b. Pressure reducing valve
c. Restrictor
d. 3-way spool valve
e. Relief valve
f. Pressure compensated flow control valve
g. 4 way valve spool
17. (In any order)
- a. Unloading valves
 - b. Counter balance valves
 - c. Flow control with a reverse check valve
 - d. Over-center

Operation of a Pressure Relief Valve

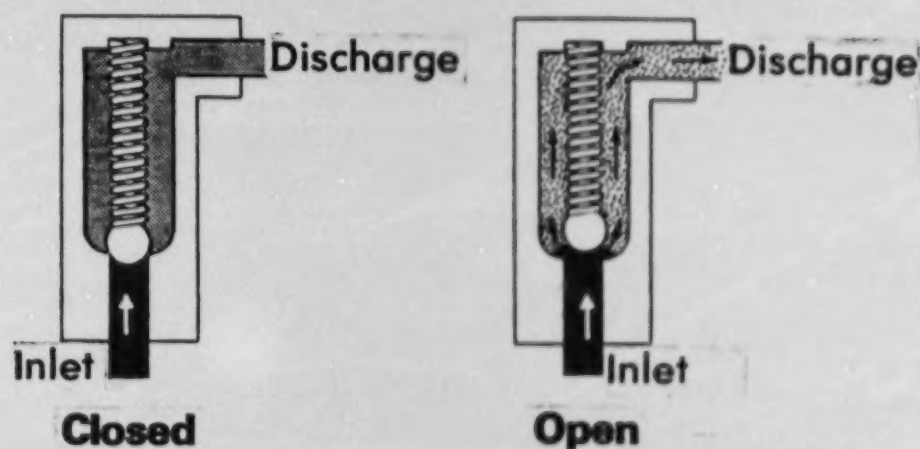


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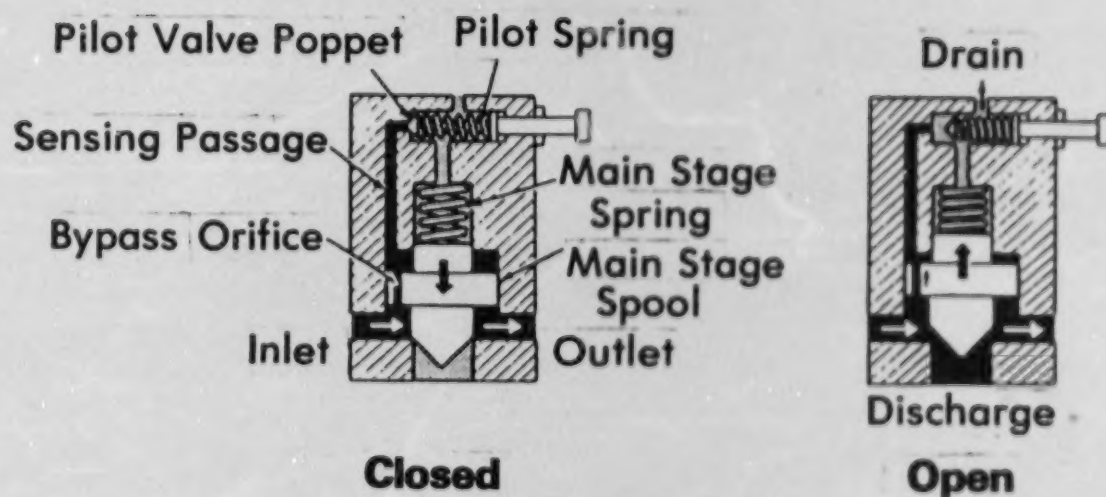
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TW 1

Types of Pressure Relief Valves

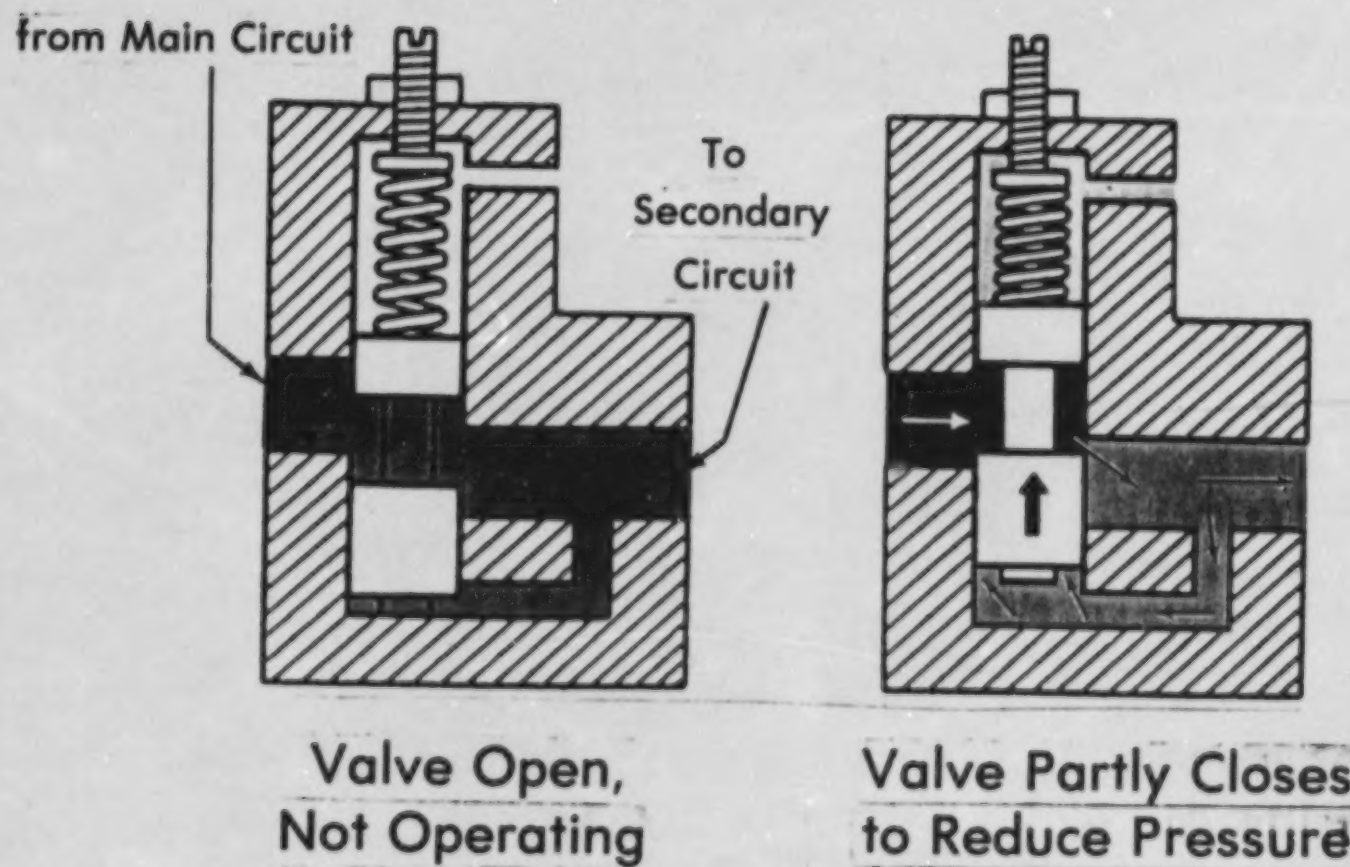


Simple



Compound

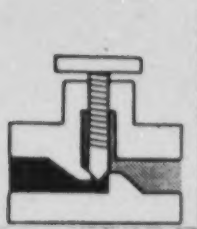
Operation of a Pressure Reducing Valve



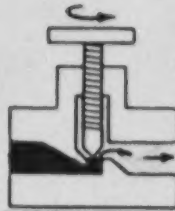
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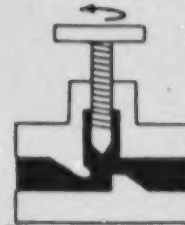
Operation of Flow Control Valves



Closed

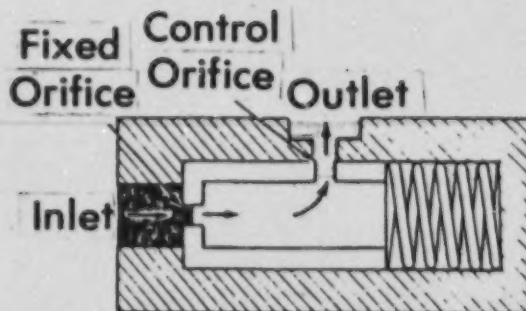


Partly Open

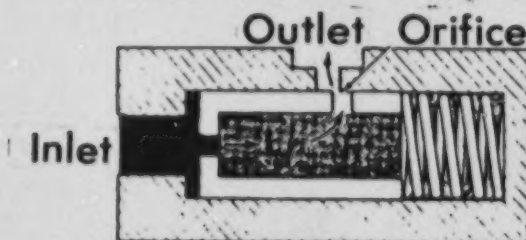


Wide Open

Needle Valve

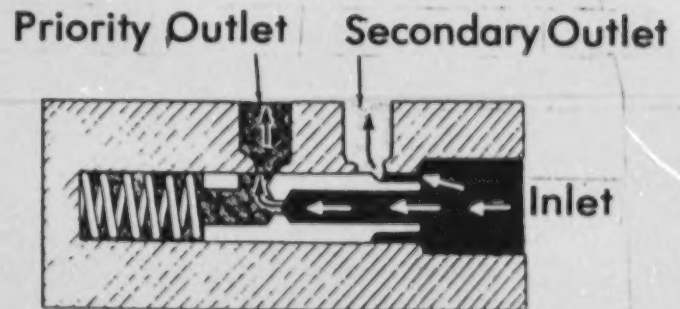


Control Orifice Fully Open

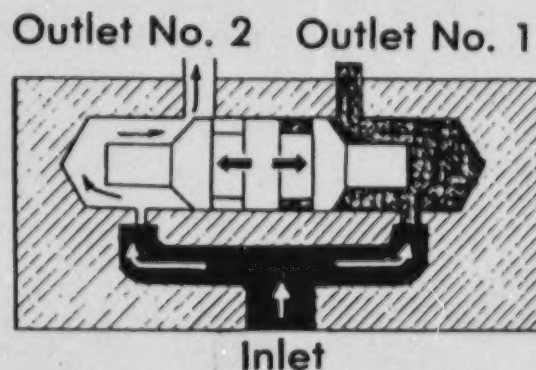


Control Orifice Partly Closed (Compensating)

Pressure Compensated Flow Control Valve

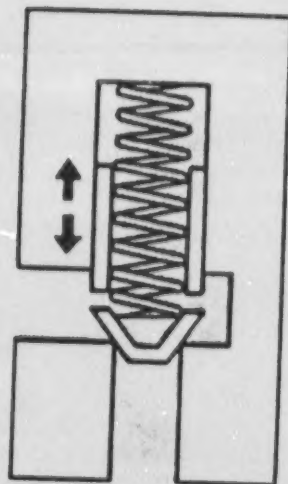


Priority Flow Divider



Proportional Flow Divider

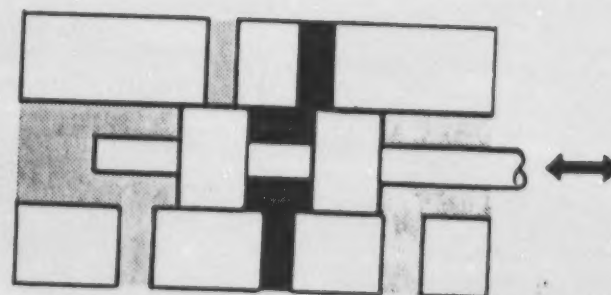
Types of Directional Control Valves



Check Valve



Rotary Valve



Spool Valve

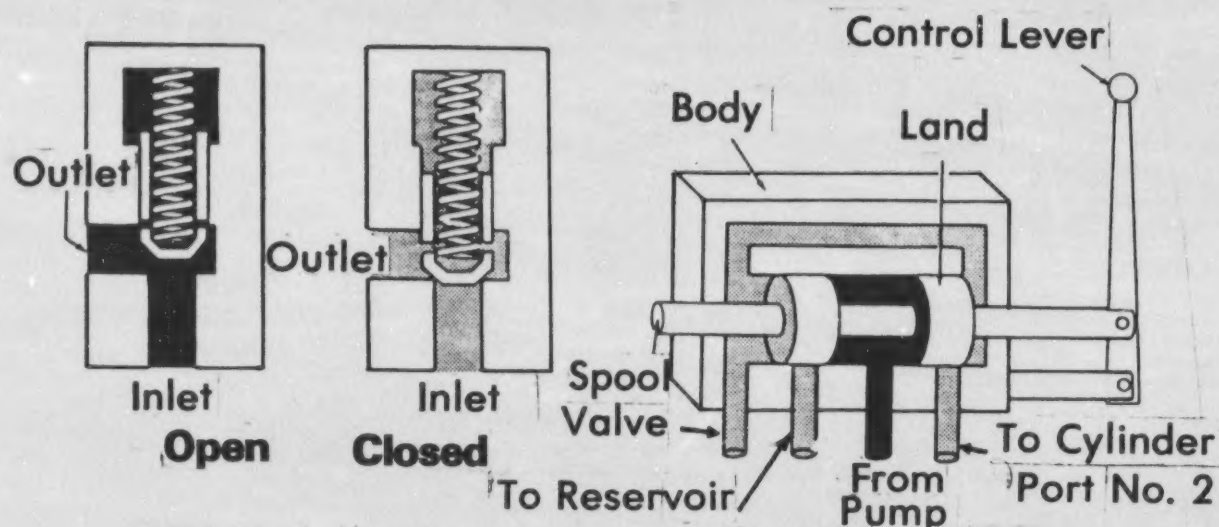
309

247

243

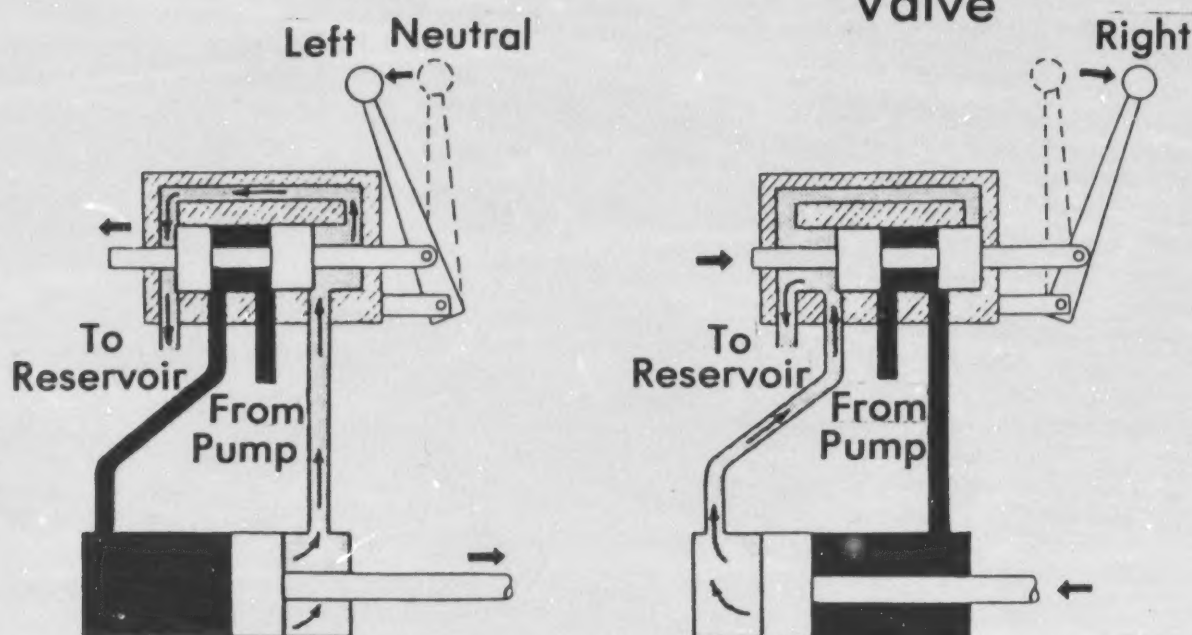
TM 5

Operation of Directional Control Valves



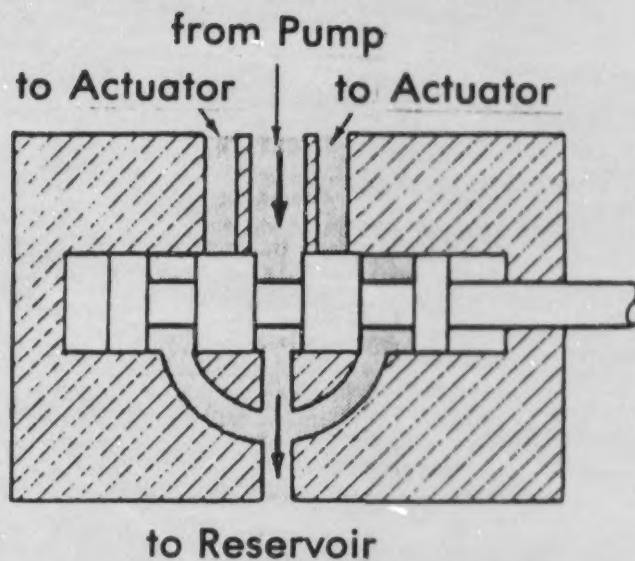
Check Valve in Operation

Spool Directional Valve

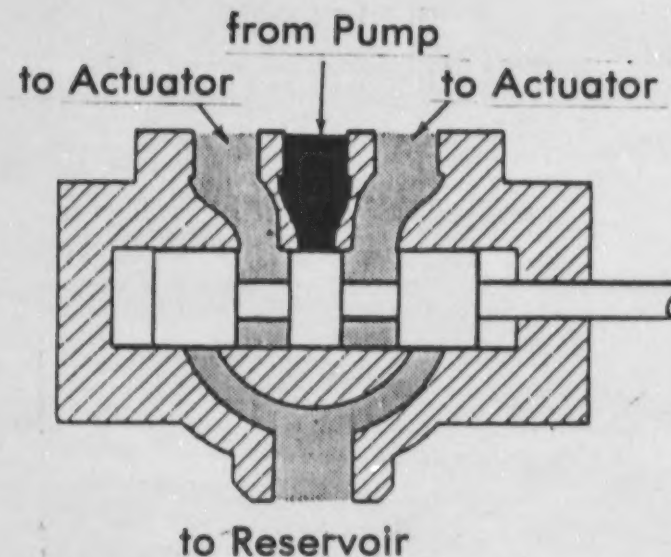


Spool Valve Directing Oil To Cylinder

Open and Closed Center Spool Valves (In Neutral)



Open Center



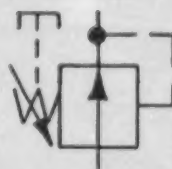
Closed Center

Symbols for Hydraulic Valves

Pressure Control



Adjustable
Relief Valve



Adjustable
Pressure Reducing Valve

Flow Control

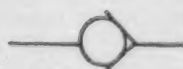


Adjustable
Restrictor

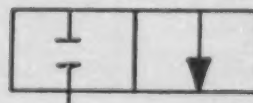


Adjustable
Pressure Compensated
Flow Control

Directional Control



Check Valve



2 Way
Spool Valve

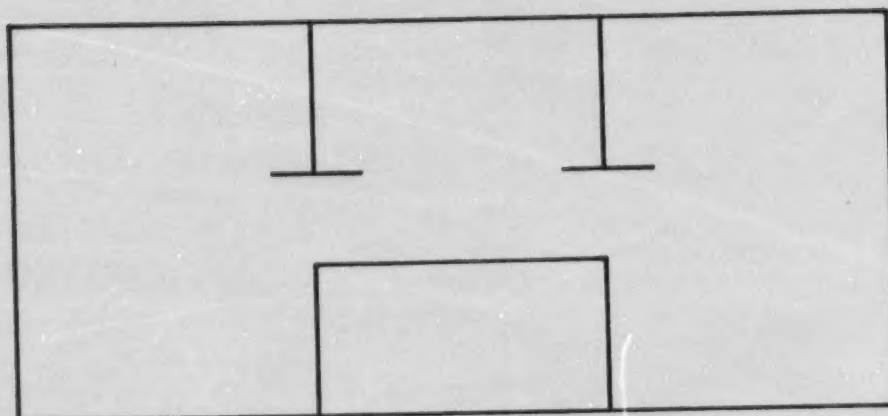


4 Way
Spool Valve

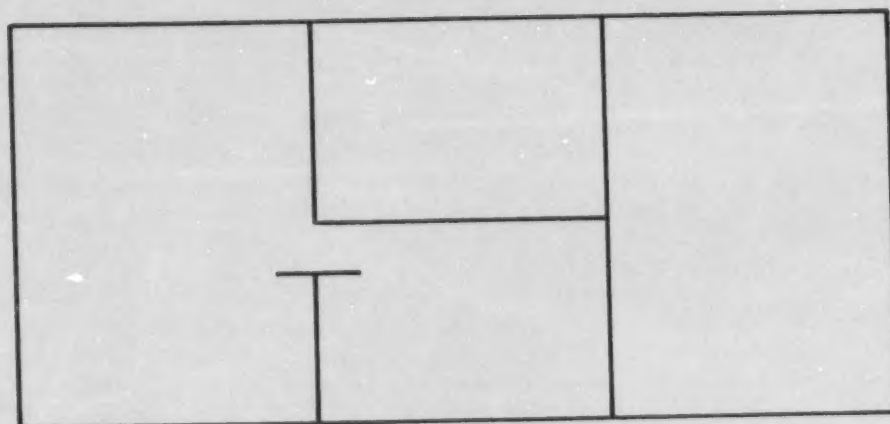


3 Way
Spool Valve

Tandem



Hydraulic Motor Spool



LESSON PLAN: 15

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

DEMONSTRATION LESSON: II-15

DISASSEMBLE, INSPECT, AND REASSEMBLE A
DIRECTIONAL CONTROL VALVE
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Disassemble a directional control valve.
2. Inspect a directional control valve.
3. Reassemble and test a directional control valve.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. Service manual for valve being serviced.

LESSON PLAN: 15

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

DEMONSTRATION LESSON: II-15

TOOLS, EQUIPMENT, AND MATERIAL

Directional control valve (NOTE: This procedure assumes that a manually operated directional control valve will be used. Other types of directional control valves may be used with minor changes to this procedure.)

Service manual if available

Hand tools

Lint free shop towels

Shipping plugs for open ports

Safety glasses

STEPS OF PROCEDURE:

I. Disassemble a directional control valve

(NOTE: Be sure spools are replaced into the openings from which they were removed. To prevent thermal expansion, avoid handling for a long period of time.)

- A. Install the shipping plugs into the valve ports.
- B. Clean the external surfaces of the valve with solvent.
- C. Place the valve in a clean area for disassembly.
- D. Remove the spool handle if not already removed.
- E. Remove the end cap.
- F. Remove the nut that holds the centering spring and remove spring.
- G. Carefully slide the spool from the valve body.

II. Inspect a directional control valve

(NOTE: After completing each point in the inspection, check the appropriate box and briefly describe the condition of the components.)

	✓	Condition
A. Examine the spool for excessive wear. (NOTE: The lands on the spool may become eroded from forces resulting from the fluid flow. Wear can also occur from contaminated fluid.)		
B. Examine the spool O-ring seals, and replace if worn or nicked.		
C. Examine the valve body for cracks.		

III. Reassemble a directional control valve

(NOTE: Lubricate all components during reassembly.)

- A. Carefully install the spool into the valve body, and use special care to insure that the O-rings are not damaged during installation.
- B. Install the centering spring and washers (if used) and retaining nut.
- C. Tighten nut.
- D. Install end cap.
- E. Install spool handle.

LESSON PLAN: 15

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-15

INTERACTION ITEMS:

1. Do we have an open, closed, tandem, or motor spool valve?
2. What is used to return the valve spool to its center position?

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

LESSON PLAN: 15

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-15

EVALUATION ITEMS:

The student has satisfactorily completed the following steps of procedure:

- I. Disassembly
- II. Inspection
- III. Reassembly and test of a directional control valve.

Yes No

Instructor's Signature
(Verifying Satisfactory Completion)

(Date)

LESSON PLAN: 16

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

INFORMATION TOPIC: II-16

CYLINDERS
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Match terms related to cylinders with the correct definitions.
2. Discuss the operation of a hydraulic cylinder.
3. Distinguish between the operation of single-acting and double-acting cylinders.
4. Identify types of double-acting cylinders.
5. Identify the parts of a single-acting cylinder.
6. Identify the parts of a double-acting cylinder.
7. List common sources of failures of hydraulic cylinders.
8. Given a formula, calculate the force output of a cylinder.
9. Given a formula, calculate the speed of a hydraulic cylinder.
10. Given a formula, calculate the power output of a cylinder.
11. Given a formula, calculate the flow rate required to move a cylinder a given distance in a given time.
12. Draw the symbol for a cylinder.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Operation of Hydraulic Cylinder
2. TM 2: Operation of Single- and Double-acting Cylinders
3. TM 3: Types of Double-acting Hydraulic Cylinders
4. TM 4: Single-acting Cylinder
5. TM 5: Double-acting Cylinder

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Co., 1979, Chap. 4.

REFERENCES: (Instructor's Additional Information)

Analyzing Hydraulic Systems. Cleveland, OH: Parker-Hannifin Corporation, 1976.

Fluid Power Designers' Lightning Reference Handbook. Orange, CA: Paul-Munroe Hydraulics, Inc., 1976.

Fluid Power 2. Cleveland, OH: Parker-Hannifin Corp., 1975.

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Co., 1979.

INTRODUCTION:

The hydraulic cylinders are the arms of our total hydraulic body. They are the means of converting hydraulic energy back into mechanical energy.

LESSON PLAN: 16

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-16

OUTLINE: (Key Points)

I. Terms and definitions

- A. **Cylinder** - an actuator which converts hydraulic power into linear mechanical force and motion
- B. **Piston area** - area of the cylinder piston
- C. **Rod area** - area of the piston rod
- D. **Rod side area** - effective area (net area) on the rod side of the cylinder; equal to the piston area minus the rod area
- E. **Back pressure** - pressure in the return lines caused by flow restriction in these lines

II. Operation of a hydraulic cylinder (TM 1)

- A. Hydraulic oil flow into a chamber of the cylinder, causing the cylinder rod to move
- B. Pressure of the fluid acting on the surface of a piston creates a force on the rod

III. Operation of single-acting and double-acting cylinders (TM 2)

A. Single-acting

- 1. Oil flows into only one side of the cylinder.
- 2. The cylinder is retracted by gravity or a spring.

B. Double-acting

- 1. Oil flows into one side to extend the cylinder.
- 2. The cylinder is retracted by oil flow into the other side of the cylinder.

IV. Types of double-acting cylinders (TM 3)

A. Balanced

(NOTE: A balanced double-acting cylinder has an equal area on both sides of the piston.)

B. Unbalanced

(NOTE: Unbalanced double-acting cylinders have unequal areas on each side of the piston.)

V. Parts of a single-acting cylinder (TM 4)

A. Piston

B. Piston rod

C. Piston seal

D. Rod seal and rod seal (pressure)

E. Air vent

F. Oil inlet

G. Cylinder housing

H. Cylinder bore

I. Mount

J. Tube seal

VI. Parts of a double-acting cylinder (TM 5)

A. Piston

B. Piston rod

C. Piston seals

D. Oil ports

E. End cap

F. Rod (pressure) seal

G. Cylinder housing

H. Cylinder bore

- I. Tube seals
- J. Cushions
- K. Mount
- L. Wiper seal

VII. Common sources of failures of hydraulic cylinders

- A. Bent rod
- B. Scored cylinder barrel
- C. Nicked or damaged rod
- D. Leaking piston seal
- E. Leaking rod seal
- F. Defective wiper seal

(NOTE: A defective wiper seal will often cause a leaking piston or rod seal or other problem.)

VIII. The force output of hydraulic cylinders

- A. Single-acting: Force = Pressure x Piston Area or $F=PA$

Example: Calculating force when pressure and area are known
 Pressure = $P = 1500$ pounds per square inch (psi)
 Piston diameter = $D = 3.0$ inches

(NOTE: $\pi = 3.14$)

$$\text{Piston area} = A = \frac{\pi D^2}{4} = \frac{3.14 (3)^2}{4} = 7.07 \text{ sq. in.}$$

$$\text{Force} = F = 1500 \text{ lbs./sq. in.} \times 7.07 \text{ sq. in.} = 10,600 \text{ lbs.}$$

Example: Calculating pressure when force and diameter are known

Force = 5,000 lbs.
 Piston Diameter = 2.0 inches

$$\text{Piston area} = A = \frac{\pi D^2}{4} = \frac{3.14 (2)^2}{4} = 3.14 \text{ sq. in.}$$

$$\text{Pressure} = P = F/A = 5,000 \text{ lbs.}/3.14 \text{ sq. in.} = 1590 \text{ psi}$$

- B. Double-acting: Force = Piston Area x Piston Pressure - Rod side Area x Rod side pressure

Example: Piston diameter = 4 inches
 Rod diameter = 2 inches
 Piston pressure = 1500 pounds per square inch (psi)
 Rod-side pressure = 500 pounds per square inch (psi)

$$\text{Piston area} = \frac{\pi D^2}{4} = \frac{3.14 (4)^2}{4} = 12.6 \text{ sq. in.}$$

$$\text{Rod area} = \frac{(3.14) (2)^2}{4} = 3.14 \text{ sq. in.}$$

$$\text{Rod-side area} = 12.56 - 3.14 = 9.42 \text{ sq. in.}$$

$$F = (1500 \text{ lbs./sq. in.}) \times (12.6 \text{ sq. in.}) - (500 \text{ lbs./sq. in.}) (9.42 \text{ sq. in.})$$

$$F = 14,190 \text{ lbs.}$$

IX. Formulas for speed of a cylinder

- A. Single-acting -

$$\text{Rod Speed} = \frac{\text{flow rate} \times 19.25}{\text{Piston area}} \text{ or } V = \frac{Q \times 19.25}{A}$$

(NOTE: This equation requires that the unit of measure of flow rate be gallons per minute (gpm) and unit of measure of piston area be square inches. The rod speed will be in feet per minute.)

Example: Flow rate into cylinder = Q = 5 gpm
 Piston Diameter = D = 3

$$\text{Then: Piston Area} = \frac{3.14 (3)^2}{4} = 7.07 \text{ sq. in.}$$

$$V = \frac{Q \times 19.25}{A} = \frac{5 \text{ gpm} \times 19.25}{7.07 \text{ sq. in.}} = 13.6 \text{ ft./min.}$$

- B. Double-acting -

$$\text{Rod speed} = \frac{\text{flow rate} \times 19.25}{\text{Area}} \text{ or } V = \frac{Q \times 19.25}{A}$$

where the area is the piston area when the rod is extending and the rod-side area when the piston is retracting

Example:

Piston Diameter = 4 in
 Rod Diameter = 2 in
 Piston Area = 12.6 sq. in.
 Rod Area = 3.14 sq. in.
 Rod-Side Area = 9.42 sq. in.

If the cylinder is extending and the flow into the piston side is 10 gpm then:

$$V = \frac{10 \text{ gpm} \times 19.25}{12.6 \text{ sq. in.}} = 15.3 \text{ ft/min.}$$

If the cylinder is retracting and the flow into the rod side is 10 gpm, then:

$$V = \frac{10 \text{ gpm} \times 19.25}{9.42 \text{ sq. in.}} = 20.4 \text{ ft/min.}$$

X. Formula for power output of a cylinder -

$$\text{Power} = \frac{V \times F}{33,000}$$

Where

V = Rod velocity (ft/sec)

F = Rod force (pounds force)

Power = Power out (horsepower)

Example:

$$V = 10 \text{ ft/sec}$$

$$F = 5000 \text{ pounds force}$$

$$\text{Power} = \frac{(10)(5000)}{33,000} = 4.5 \text{ hp}$$

XI. Formula for the flow rate required to move a cylinder a given distance in a given time:

$$Q = \frac{A \times L}{T \times 231}$$

Where:

Q = Flow rate in gallons per minute (gpm)

A = Area in square inches (in²)

L = Length in inches (in)

T = Time in minutes

Example:

To move a 2 inch diameter cylinder 20 inches in 0.5 minute the flow rate required is 0.54 gpm.

$$A = \frac{\pi D^2}{4} = 3.14(2^2) = 3.14 \text{ in}^2$$

$$Q = \frac{(3.14) \times 20 \text{ inches}}{0.5 \text{ minutes} \times 231} = 0.54 \text{ gpm}$$

XII. Symbol for a cylinder



LESSON PLAN: 16

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-16

INTERACTION ITEMS: (Review Items)

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

Have a small hydraulic cylinder to disassemble and to pass around the room while the lesson is being presented. Another option would be to have the various parts displayed for the students to inspect.

LESSON PLAN: 16

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-16

EVALUATION ITEMS:

1. Match the terms on the right with the correct definitions.

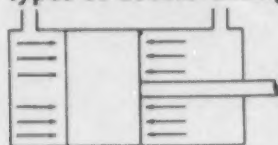
- | | | | |
|-----------------------------|---|----|---------------|
| ☐ a. | Area of the piston rod | 1. | Piston area |
| ☐ b. | Area of the cylinder piston | 2. | Back pressure |
| ☐ c. | Effective area on the rod side of the cylinder; equal to the piston area minus the rod area | 3. | Rod area |
| ☐ d. | An actuator which converts hydraulic power into linear mechanical force and motion | 4. | Rod side area |
| ☐ e. | Pressure in the return lines caused by flow in these lines | 5. | Cylinder |

2. Discuss the operation of a hydraulic cylinder.

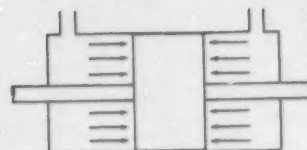
3. Distinguish between the operation of single-acting and double-acting cylinders by placing an "X" next to the descriptions of single-acting cylinders.

- ☐ a. Oil flows into only side of the cylinder.
- ☐ b. The cylinder is retracted by oil flow into the other side of the cylinder.
- ☐ c. The cylinder is retracted by gravity or a spring.
- ☐ d. Oil flows into one side to extend the cylinder.

4. Identify types of double-acting cylinders.

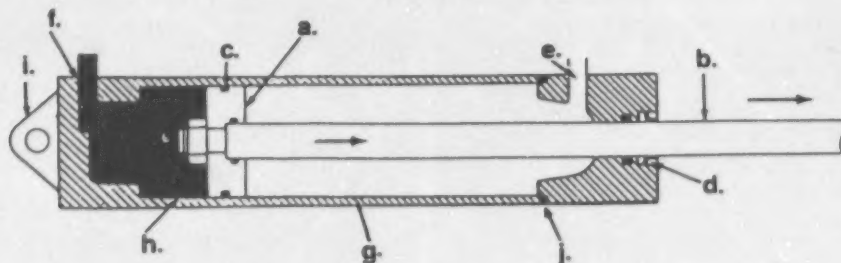


a. _____



b. _____

5. Identify the parts of a single-acting cylinder.



a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

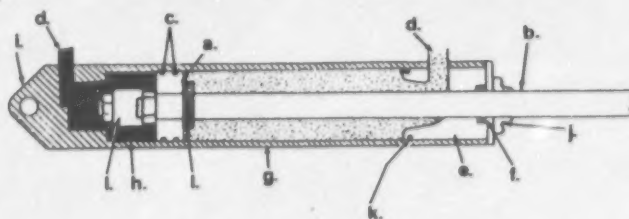
g. _____

h. _____

i. _____

j. _____

6. Identify the parts of a double-acting cylinder.



a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

g. _____

h. _____

i. _____

j. _____

k. _____

l. _____

7. List five common sources of failure of hydraulic cylinders.

- a. _____
- b. _____
- c. _____
- d. _____
- e. _____

8. Calculate the force output in the following problems

a. Using the formula for single-acting force, $F = PA$, calculate the force if $P = 2000$ psi and $D = 4.00$ inches

b. Using the formula for double-acting force, Piston Area x Piston pressure, and Rod side area x Rod side pressure, calculate the force when:

Piston pressure = 2000 psi
Rod diameter = 3.0 inches
Piston diameter = 4.00 inches
Rod-side pressure = 500 psi

9. Calculate the speed of hydraulic cylinders in the following problems.

a. Using the formula for single-acting rod speed, flow rate x 19.25/Piston area, calculate rod speed when

Flow rate into cylinder = $Q = 10$ gpm
Piston diameter = $P = 4$ inches
Constant = 19.25

- b. Using the formula for double-acting rod speed, $\frac{\text{flow rate} \times 19.25}{\text{area}}$, calculate the retracting and extending speed when

Piston diameter = 3 inches
Rod diameter = 2 inches
Piston area = 7.07 sq. in.
Rod area = 3.14 sq. in.
Rod side area = 3.93 sq. in.
Flow rate = 10 gpm

1. Retracting speed _____
 2. Extending speed _____
10. Using the formula for power output of a cylinder, $\frac{V \times F}{33,000}$, calculate the power output of a cylinder, when
- V = Rod velocity = 20 ft./sec.
F = Rod force = 10,000 pounds force
Constant = 33,000
11. Using the formula for the flow rate required to move a cylinder a given distance in a given time, $\frac{Q = A \times L}{T \times 231}$, calculate the flow rate required to move a 2 inch diameter cylinder 10 inches in one minute.
12. Draw the symbol for a cylinder.

LESSON PLAN: 16

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-16

ANSWERS TO EVALUATION ITEMS:

1. a. 3 c. 4
 b. 1 d. 5
 e. 2
2. Discussion should include:
 - a. Hydraulic oil flows into a chamber of the cylinder, causing the cylinder rod to move.
 - b. Pressure of the fluid acting on the surface of a piston creates a force on the rod.
3. a, c
4. a. Unbalanced
 b. Balanced
5. a. Piston
 b. Piston rod
 c. Piston seal
 d. Rod wiper seal
 e. Air vent
 f. Oil inlet
 g. Cylinder housing
 h. Cylinder bore
 i. Mount
 j. Tube seals
6. a. Piston
 b. Piston rod
 c. Piston seals
 d. Oil ports
 e. End cap
 f. Rod seal
 g. Cylinder housing
 h. Cylinder bore
 i. Mount
 j. Wiper seal
 k. Tube seals
 l. Cushions

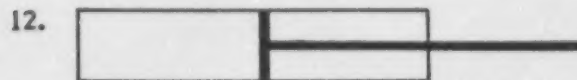
7. Any five of the following:
- a. Bent rod
 - b. Scored cylinder barrel
 - c. Nicked or damaged rod
 - d. Leaking piston seal
 - e. Leaking rod seal
 - f. Defective wiper seal

8. a. 25, 120 lbs.
b. 22, 157.5 lbs.

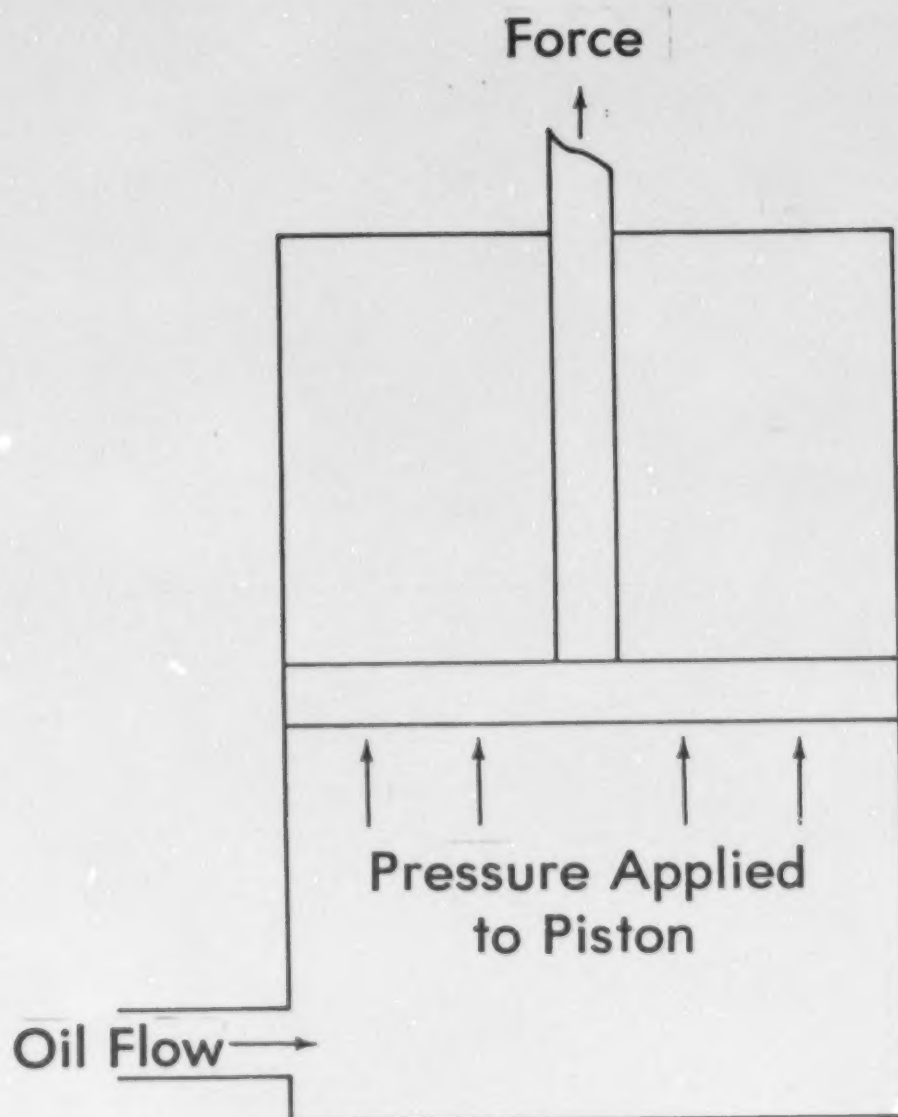
9. a. 15.33 ft/min
b. 1) 48.98 ft/min
2) 15.33

10. 6.06 hp

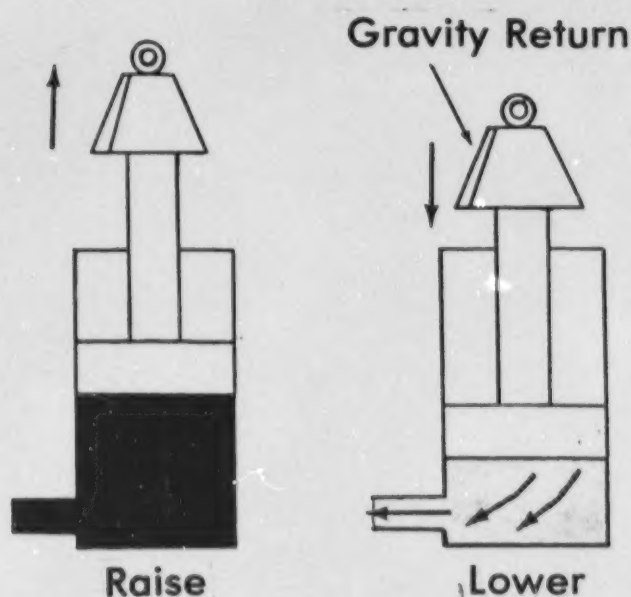
11. .136 gpm



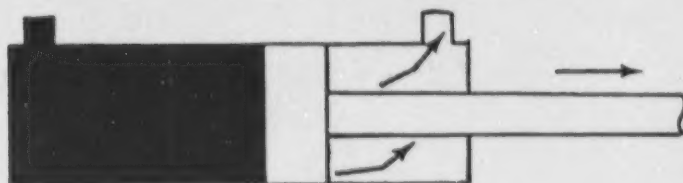
Operation of a Hydraulic Cylinder



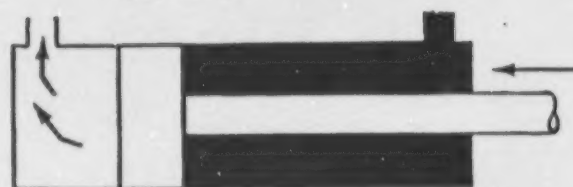
Operation of Single - and Double-Acting Cylinders



Single-Acting



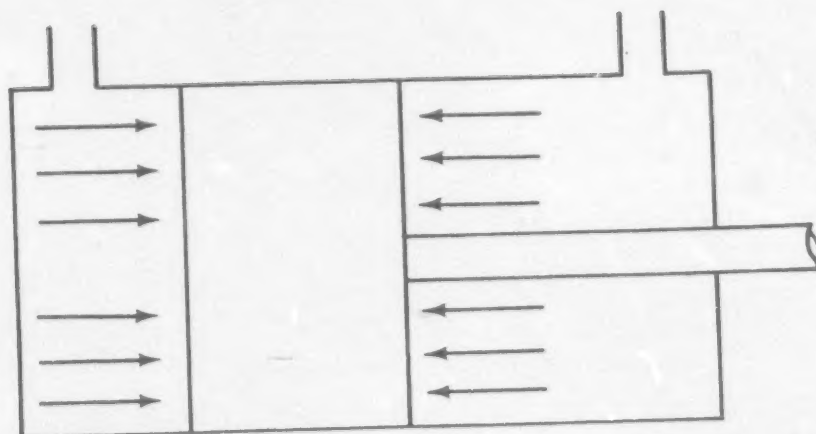
Extend



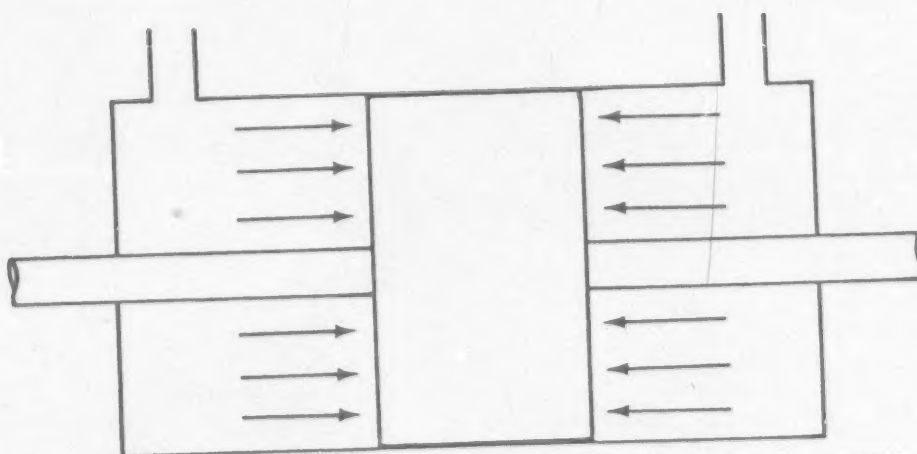
Retract

Double-Acting

Types of Double-Acting Hydraulic Cylinders

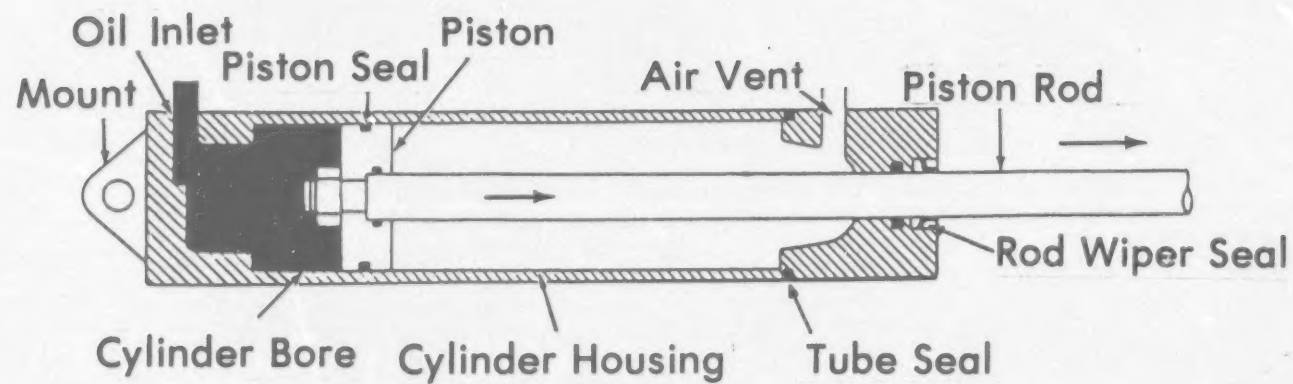


Unbalanced (Differential Type)



Balanced (Equal force both ways)

Single-Acting Cylinder

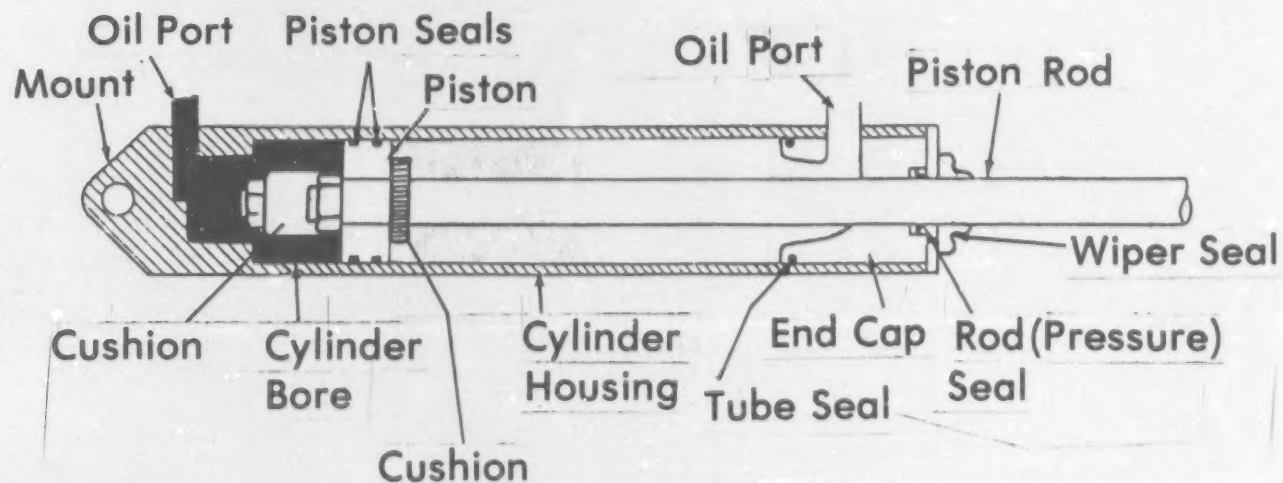
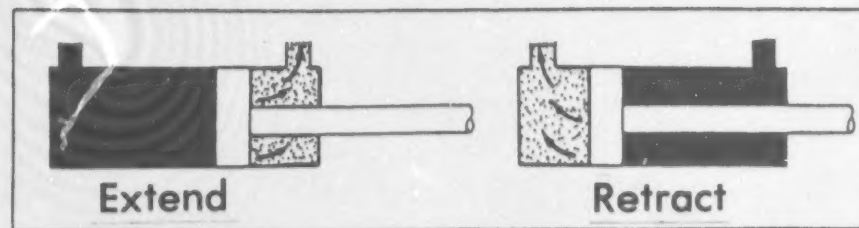


276

277

TM 4

Double-Acting Cylinder



351

278

279

TW 5

LESSON PLAN: 17

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

INFORMATION TOPIC: II-17

HYDRAULIC MOTORS
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Match terms associated with hydraulic motors with the correct definitions.
2. Name three kinds of hydraulic motors.
3. Given a formula, calculate hydraulic motor load torque.
4. Given a formula, calculate the displacement of a hydraulic motor.
5. Given a formula, calculate the speed of a hydraulic motor.
6. Given a formula, calculate hydraulic motor inlet pressure.
7. Given a formula, calculate hydraulic motor input and output power.
8. Given a formula, calculate motor overall efficiency.
9. Select true statements concerning the operation of a gear motor.
10. Select true statements concerning the operation of an unbalanced vane motor.
11. Name three types of piston motors.
12. Select true statements concerning the operation of an in-line axial piston motor.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Motor Load Torque
2. TM 2: Operation of a Gear and Vane Motor
3. TM 3: Operation of an In-Line Axial Piston Motor

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Co., 1979, Chap. 5.

REFERENCES: (Instructor's Additional Information)

Fluid Power 1. Cleveland, OH: Parker-Hannifin Corporation, 1975.

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Co., 1979.

INTRODUCTION:

Today, we are going to study a type of actuator called the hydraulic motor. This type of motor provides continuous motion to move farm equipment and construction equipment, and has many industrial applications.

LESSON PLAN: 17

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-17

OUTLINE: (Key Points)

I. Terms and definitions

- A. **Hydraulic motor** - a device for converting fluid energy into mechanical force and motion
- B. **Torque** - a measure of rotational (twisting) load or effort; calculated as force times distance
- C. **Displacement** - the volume of fluid which is transported from the motor inlet to the outlet during one revolution of the motor
- D. **Efficiency** - the output power divided by the input power
- E. **Foot-pound** - a unit of torque equal to 12 inch-pounds
(NOTE: Foot-pounds are abbreviated ft-lbs.)
- F. **Back-pressure** - pressure at the outlet of a motor caused by pressure drop in the return lines

II. Kinds of hydraulic motors

- A. Gear
- B. Vane
- C. Piston

(NOTE: These are positive displacement motors. Nonpositive displacement motors do exist but are not commonly used in hydraulic systems.)

- III. Formula for calculation of hydraulic motor load torque (TM 1):
Torque = Distance x Force

Where Torque is expressed in ft-pounds or inch-pounds
Force = Load force expressed in pounds
Distance = Distance from center of shaft to line of action of applied force, measured perpendicular to line of action of force and expressed in units of inches or feet

Example: If a 100 pound force is applied to the shaft of a hydraulic motor one foot from the center of the shaft, then the output torque is 100 ft-pounds

$$\begin{aligned}\text{Torque} &= \text{Distance} \times \text{Force} \\ \text{Torque} &= (1 \text{ ft}) (100 \text{ pounds}) = 100 \text{ ft-pounds}\end{aligned}$$

- IV. Formula for calculating the displacement of a hydraulic motor: $d = \frac{231 Q}{n}$

Where: d = Displacement in units of cubic inches per revolution (in^3/rev)
 Q = Motor inlet flow rate in units of gallons per minute (gpm)
 n = Shaft speed in units of revolutions per minute (rpm)

Example: The displacement of a motor which has a shaft speed of 1800 rpm when the inlet flow rate is 20 gpm is $2.56 \text{ in}^3/\text{rev}$.

$$d = \frac{231 \times 20 \text{ gpm}}{1800 \text{ rpm}} = 2.56 \text{ in}^3/\text{rev}.$$

- V. Formula for calculating the speed of a hydraulic motor: $n = \frac{Q \times 231}{d}$

Where n = Shaft speed in units of revolutions per minute (rpm)
 Q = Motor inlet flow rate in units of gallons per minute (gpm)
 d = Displacement in units of cubic inches per revolution (in^3/rev)

Example: The speed of a $2.56 \text{ in}^3/\text{rev}$ motor with an inlet flow rate of 25 gpm is 2255 rpm

$$\begin{aligned}m &= (25 \text{ gpm}) \times 231 = 2255 \text{ rpm} \\ &2.56 \text{ in}^3/\text{rev}\end{aligned}$$

- VI. Formula for calculating hydraulic motor inlet pressure: $P = \frac{\text{Torque} \times 2}{d}$

(NOTE: = 3.14)

Where P = Inlet pressure in units of pounds per square inch (psi)
Torque = Shaft torque in units of inch-pounds (in.-lbs.)
 d = displacement in cubic inches per revolution (in^3/rev)

Example: A hydraulic motor has a displacement of 2.56 cubic inches per revolution. The load torque is 700 in-lbs. The inlet pressure is 1717 psi.

$$P = \frac{(700 \text{ in-lbs.}) \times 6.28}{2.56} = 1700$$

VII. Formula for calculating hydraulic motor power

A. Input power: $\text{power} = \frac{P \times Q}{1714}$

Where Power = Input in units of horsepower (hp)
 P = Inlet pressure in units of psi
 Q = Inlet flow rate in units of gpm

Example: The input power of a hydraulic motor operating at 20 gpm inlet flow and 3000 psi inlet pressure is 35 hp

$$\text{Power} = \frac{3000 \text{ psi} \times 20 \text{ gpm}}{1714} = 35 \text{ hp}$$

B. Output power: $\text{Power} = \frac{n \times \text{Torque}}{5252}$

Where Power = Output power in units of horsepower (hp)
 n = Shaft speed in units of revolutions per minute (rpm)
 Torque = Output torque in units of foot-pounds (ft-lbs)

Example: The output power of a hydraulic motor operated at 2400 rpm with an output load of 70 ft-lbs is 32 hp

$$\text{Power} = \frac{(2400 \text{ rpm})(70 \text{ ft-lbs.})}{5252} = 32 \text{ hp}$$

VIII. Formula for the calculation of motor overall efficiency:

$$\text{Eff} = \frac{\text{Output power}}{\text{Input power}}$$

Example: A motor is operated at the output power of 27 hp. The input power required is 32 hp. The efficiency is 0.844.

$$\text{Eff} = \frac{27}{32} = 0.844; \text{ Therefore the motor is 84.4\% efficient.}$$

IX. Operation of a gear motor (TM 2)

- A. Pressurized hydraulic fluid is supplied to the inlet of the motor.
- B. The pressure creates a force on the face of each gear tooth.

- B. In-line axial
- C. Bent axis axial

XII. Operation of an in-line axial piston motor (TM 3)

- A. The motor consists of a swash plate, pistons with shoes, a cylinder barrel, shaft, and port plate.
- B. The pistons are installed in the cylinder barrel and are connected with the swash plate.
- C. The swash plate is positioned at an angle causing the pistons to extend varying distances into the cylinder block.
- D. Pressurized hydraulic fluid is supplied to the inlet of the motor, which causes a force to be applied to the top of a piston.
- E. This, in turn, causes the piston and shoe to slide on the swash plate from the high side to the low side causing the cylinder barrel and shaft to rotate (TM 3).

(NOTE: The swash plate does not rotate with the pistons, cylinder barrel and shaft.)

- F. As each piston is forced to move, it rotates from the inlet to the outlet.
- G. As the piston rotates, it carries a small amount of fluid from the inlet to outlet.
- H. This fluid is expelled from the outlet at a lower pressure.

LESSON PLAN: 17

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-17

INTERACTION ITEMS: (Review Items)

1. What is the difference between a pump and a motor?

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

Have parts of pumps for students to examine.

LESSON PLAN: 17

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-17

EVALUATION ITEMS:

1. Match the terms on the right with the correct definitions.

- | | | |
|--------|--|--------------------|
| ___ a. | A measure of rotational load or effort; calculated as force times distance | 1. Back pressure |
| ___ b. | The output power divided by the input power | 2. Hydraulic motor |
| ___ c. | The volume of fluid which is transported from the motor inlet to the outlet during one revolution of the motor | 3. Displacement |
| ___ d. | A device for converting fluid energy into mechanical force and motion | 4. Torque |
| ___ e. | A unit of torque equal to 12 inch-pounds | 5. Efficiency |
| ___ f. | Pressure at the outlet of a motor caused by pressure drop in the return lines | 6. Foot-pound |

2. Name three kinds of hydraulic motors.

- a.
- b.
- c.

3. Using the formula for torque, calculate hydraulic motor load torque if a 150 pound force is applied to the shaft of a hydraulic motor two feet from the center of the shaft.

Torque = Distance x Force

4. Using the formula for displacement, calculate the displacement of a motor which has a shaft speed of 1750 rpm when the inlet flow rate is 22 gpm.

$$d = \frac{231 Q}{n}$$

5. Using the formula for speed, calculate the speed of a 2.56 in³/rev. hydraulic motor with an inlet flow rate of 24 gpm.

$$n = \frac{Q \times 231}{d}$$

6. Using the formula for inlet pressure, calculate inlet pressure of a hydraulic motor which has a displacement of 2.56 cubic inches per revolution and a load torque of 750 in-lbs.

$$P = \frac{\text{Torque} \times 2 \pi}{d}$$

7. a. Using the formula for input power, calculate the input power of a motor operating at 21 gpm inlet flow and 2500 psi inlet pressure.

$$\text{Power} = \frac{P \times Q}{1714}$$

- b. Using the formula for output power, calculate the output power of a motor which is operating at 2000 rpm with an output load of 50 ft-lbs.

$$\text{Power} = \frac{n \times \text{Torque}}{5252}$$

8. Calculate the motor overall efficiency if the output power is 25 hp and the input power is 30 hp using this formula.

$$\text{Eff} = \frac{\text{Output power}}{\text{Input power}}$$

9. Select true statements concerning the operation of a gear motor by placing an "X" in the appropriate blanks.

- ☐ a. Pressurized hydraulic fluid is supplied to the inlet of the motor.
- ☐ b. The pressure creates a force on the face of each gear tooth.
- ☐ c. The pressure force on the gear teeth is balanced; a force on one face which would tend to cause rotation in the clockwise direction is balanced by a force on an adjacent face which would tend to cause rotation in the opposite direction.
- ☐ d. This balancing of forces exists at all gear teeth except where the teeth just begin to disengage.
- ☐ e. At this location, the forces are not balanced which tends to cause the motor to rotate.
- ☐ f. As the motor rotates, small volumes of fluid are trapped between the gear teeth and are carried to the outlet.
- ☐ g. The fluid at the outlet is expelled at a much higher pressure.

10. Select true statements concerning the operation of an unbalanced vane motor by placing an "X" in the appropriate blanks.

- ☐ a. A vane motor consists of a ring, vanes, rotor, shaft, and a port plate with kidney shaped inlet and outlet ports.
- ☐ b. The rotor is installed in the center of the ring.
- ☐ c. The vanes are installed into the port plate and cannot move.
- ☐ d. The vanes are spring-loaded to force the vanes to contact the surface of the ring.
- ☐ e. Pressurized hydraulic fluid is supplied to the inlet of the motor.
- ☐ f. At this point the vanes are balanced and the rotor turns.
- ☐ g. As the rotor turns a small volume of fluid is trapped and carried to the outlet and expelled at a lower pressure.

11. Name three types of piston motors.

a.

b.

c.

12. Select true statements concerning the operation of an in-line axial piston motor by placing an "X" in the appropriate blanks.

- ☐ a. The motor consists of a swash plate, pistons with shoes, a cylinder barrel, shaft, and port plate.
- ☐ b. The swash plate is positioned at an angle thus causing the pistons to extend into the cylinder block a varying amount.
- ☐ c. Pressurized hydraulic fluid is supplied to the inlet of the motor, which causes a force to be applied to the shaft.
- ☐ d. This, in turn, causes the piston and shoe to slide on the swash plate from the high side to the low side, causing the cylinder barrel and shaft to rotate.
- ☐ e. As each piston is forced to move, it rotates from the outlet to the inlet.
- ☐ f. As the piston rotates, it carries a small amount of fluid from the inlet to the outlet.
- ☐ g. This fluid is expelled from the outlet at a lower pressure.

LESSON PLAN: 17

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

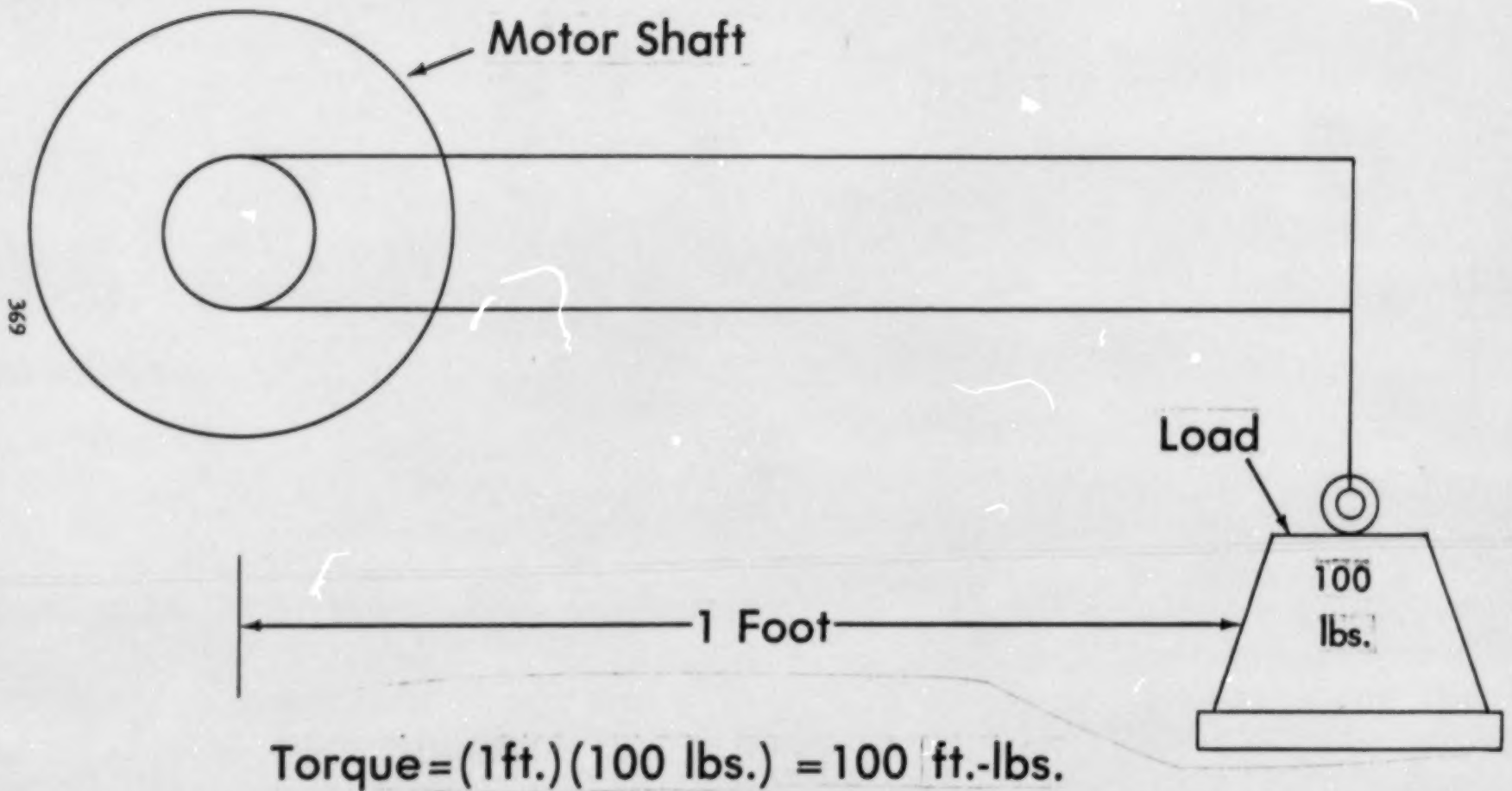
UNIT II : COMPONENTS

INFORMATION TOPIC: II-17

ANSWERS TO EVALUATION ITEMS:

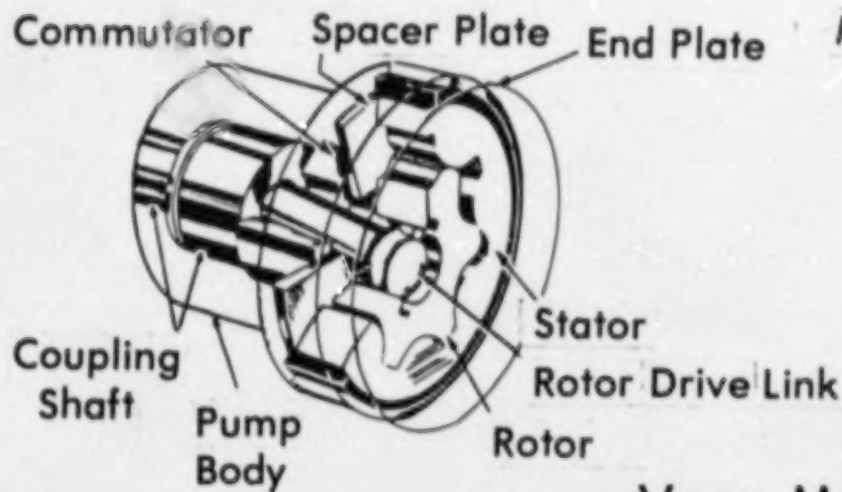
1. a. 4 d. 2
 b. 5 e. 6
 c. 3 f. 1
2. a. Gear
 b. Vane
 c. Piston
3. 300 ft-lbs.
4. 2.9 in³/rev.
5. 2165 rpm
6. 1840 psi
7. a. 30.6 hp
 b. 19 hp
8. 83%
9. a, b, c, d, e, f
10. a, d, e, g
11. a. Radial
 b. In-line axial
 c. Bent axis axial
12. a, b, d, f, g

Motor Load Torque



Operation of a Gear and Vane Motor

Internal Gear Motor

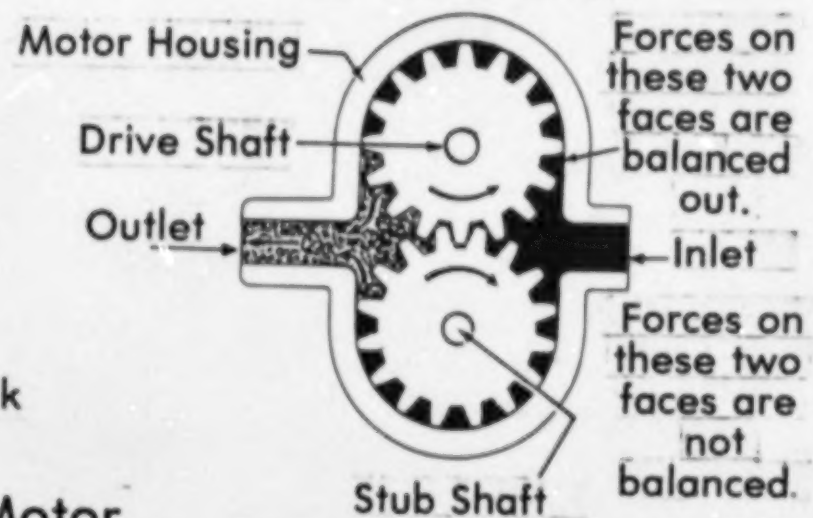


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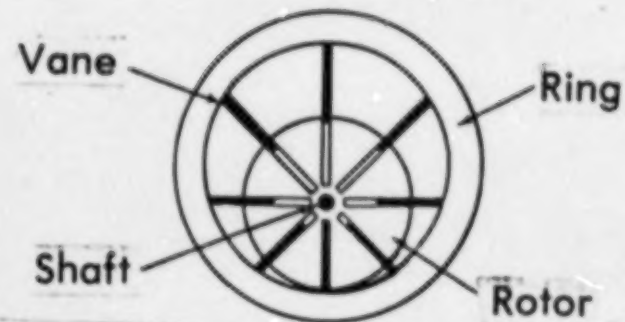


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External Gear Motor in Operation



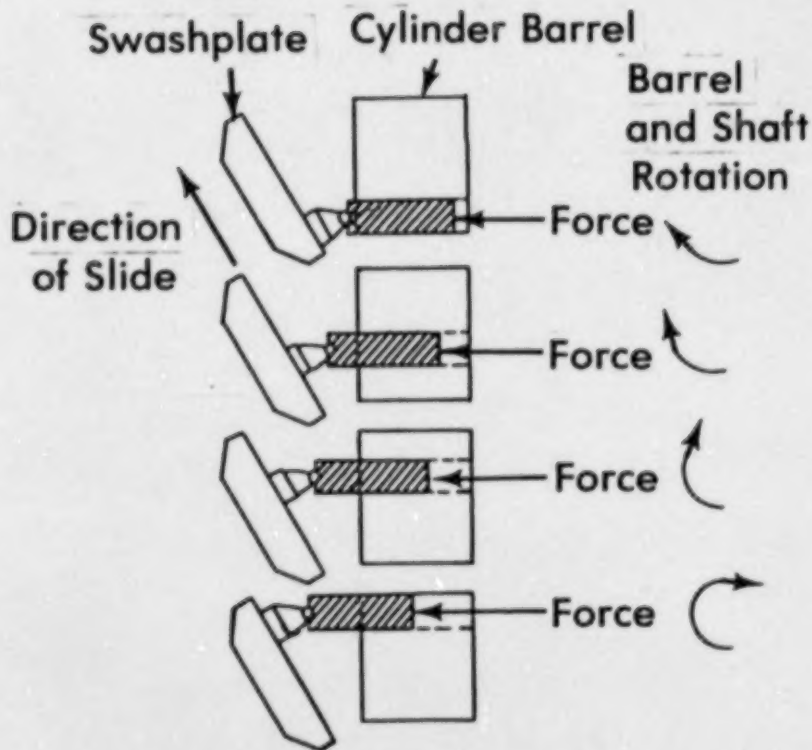
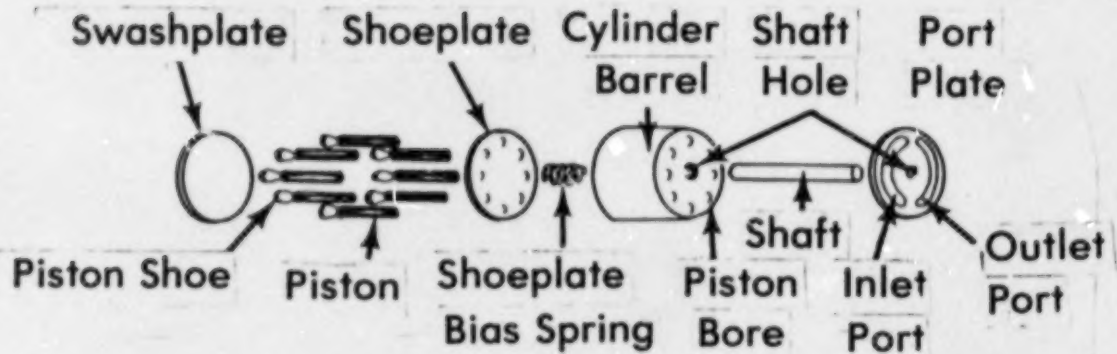
Vane Motor



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TM 2

Operation of an In-Line Axial Piston Motor



LESSON PLAN: 18

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

SCOPE OF UNIT:

After completion of this unit, the student will be familiar with hydraulic system components, their functions, construction, and applications.

INFORMATION TOPIC: II-18

HYDRAULIC ACCESSORIES
(Lesson Title)

LESSON OBJECTIVES - THE STUDENT SHOULD BE ABLE TO:

1. Define terms associated with accessories.
2. Select functions of an accumulator.
3. Identify types of accumulators.
4. Identify types of gas-loaded accumulators.
5. List safety precautions for working with accumulators.
6. Explain reasons for using a heat exchanger.
7. Describe types of heat exchangers.
8. List common failures of heat exchangers.
9. Explain reasons for using a heater.
10. Describe two types of heaters.
11. List two common failures of heaters.

SUPPLEMENTARY TEACHING/LEARNING ITEMS:

1. TM 1: Types of Accumulators
2. TM 2: Types of Gas-Loaded Accumulators
3. TM 3: Types of Heat Exchangers

INFORMATIONAL ASSIGNMENT: (Student)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Co., 1979, Chaps. 6 and 8.

REFERENCES: (Instructor's Additional Information)

Fundamentals of Service, Hydraulics. Moline, IL: Deere and Company, 1979.

INTRODUCTION:

A spring is the simplest example of an accumulator. When compressed, a spring becomes a source of potential energy. It can also be used to absorb shocks or to control the force on a load. Hydraulic accumulators work in much the same way. Basically they are containers which store fluid under pressure.

LESSON PLAN: 18

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-18

OUTLINE: (Key Points)

- I. Terms and definitions
 - A. **Accumulator** - a device for storing hydraulic energy
 - B. **Heat exchanger** (hydraulic cooler) - a device for removing heat from hydraulic fluids
 - C. **Heater** - a device for adding heat to hydraulic fluids
 - D. **Thermostat** - an automatic device for regulating temperature
- II. Functions of an accumulator
 - A. Stores energy
 - B. Absorbs shock
 - C. Allows the system to build pressure gradually
 - D. Maintains pressure
- III. Types of accumulators (TM 1)
 - A. Gas-loaded (gas-charged)
 - B. Weight-loaded
 - C. Spring-loaded
- IV. Types of gas-loaded accumulators (TM 2)
 - A. Piston type
 - B. Bladder type
 - C. Diaphragm type

V. Safety precautions for working with accumulators

(NOTE: Accumulators are used to store energy and therefore can pose severe safety hazards.)

- A. **Always** discharge stored hydraulic fluid from the accumulator prior to removing the accumulator from the system.

(NOTE: Valves, brake pedals, etc., should be operated to insure all stored hydraulic energy has been expelled. Failure to do this could result in severe injury from high pressure fluid escaping.)

- B. Never charge an accumulator to a pressure more than that recommended by the manufacturer.
- C. **Never** fill an accumulator with oxygen; an explosion could result if oil and oxygen mix.
- D. Only fill the accumulator with an inert gas such as dry nitrogen, because dry nitrogen is free of water vapor and oxygen.

(NOTE: Allowing water vapor to enter the accumulator can cause the accumulator to rust.)

- E. Do not use compressed air in an accumulator.
- F. Before disassembling an accumulator release both gas and hydraulic pressures.
- G. Use extreme care in removing the springs from spring-loaded accumulators.

VI. Reasons for using a heat exchanger

- A. Power losses (inefficiencies) in various hydraulic components, such as pumps, valves, and lines, result in heating of the hydraulic fluid.
- B. In order to prevent excessive operating temperatures, this heat must be removed.
- C. The heat exchanger removes heat from the hydraulic system.

VII. Types of heat exchangers (TM 3)

- A. Air-to-oil cooler - uses air moving past a radiator to dissipate the heat

(NOTE: Altitude will affect effectiveness of this type of cooler.)

- B. Water-to-oil cooler - uses water flowing through tubes immersed in the oil to remove the heat

VIII. Common failures of heat exchangers

- A. Cooling fins on air-to-oil heat exchangers become clogged with dirt and debris.
- B. Water tubes on water-to-oil heat exchangers become plugged with sediment.
- C. Water leaks into fluid.
- D. Fluid leaks into water.

IX. Reasons for using a heater

- A. The viscosity of hydraulic fluid is sensitive to temperature; at cold temperatures the fluid is thick and severe pressure losses can occur in the lines.
- B. In cold environments, heaters are often used to help raise the temperature to the desired operating temperature or to help maintain the desired operating temperature.

X. Types of heaters

- A. Electric - uses electrical heating element to add heat to the system
- B. Heat exchanger - uses the same principle as when used to cool, except hot air or liquid is used to add heat rather than remove it

XI. Common failures of heaters

- A. Electrical heating element fails
- B. Heat exchanger fails

LESSON PLAN: 18

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

INFORMATION TOPIC: II-18

INTERACTION ITEMS: (Review Items)

1. How can you store potential energy for use at a later time and/or under specific conditions.

CLASSROOM, LABORATORY, SHOP, OR OTHER ACTIVITIES:

LESSON PLAN: 18

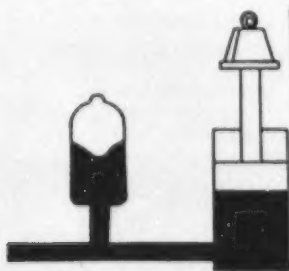
COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

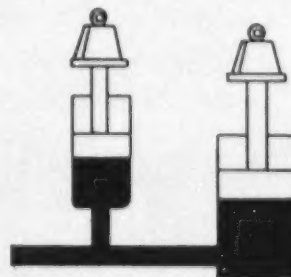
INFORMATION TOPIC: II-18

EVALUATION ITEMS:

1. Define terms associated with accessories.
 - a. Accumulator -
 - b. Heat exchanger -
 - c. Heater -
 - d. Thermostat -
2. Select functions of an accumulator by placing an "X" in the appropriate blanks.
 - ☐ a. Provides cooling for the system
 - ☐ b. Absorbs shocks
 - ☐ c. Allows the system to build pressure gradually
 - ☐ d. Stores energy
 - ☐ e. Filters dirt particles
 - ☐ f. Maintains pressure
3. Identify the types of accumulators.



a. _____



b. _____

6. Explain reasons for using a heat exchanger.

7. Describe types of heat exchangers.

a. Air-to-oil cooler -

b. Water-to-oil-cooler -

8. List three common failures of heat exchangers.

a.

b.

c.

9. Explain reasons for using a heater.

a.

b.

10. Describe two types of heaters.

a. Electric -

b. Heat exchanger -

11. List two common failures of heaters.

a.

b.

LESSON PLAN: 18

COURSE TITLE: FLUID POWER/BASIC HYDRAULICS

UNIT II : COMPONENTS

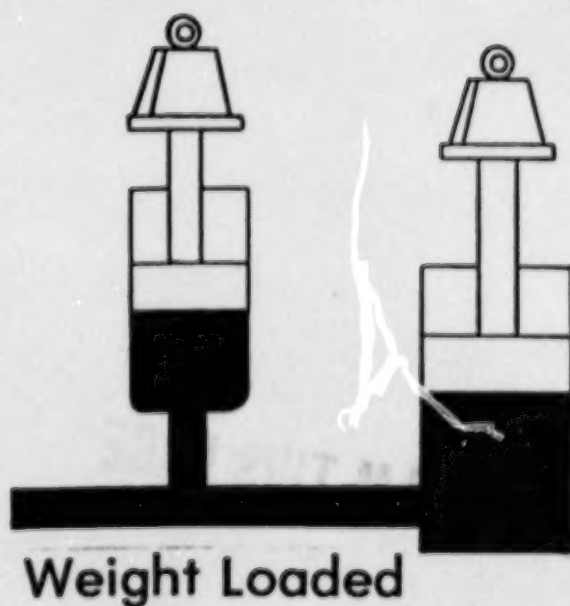
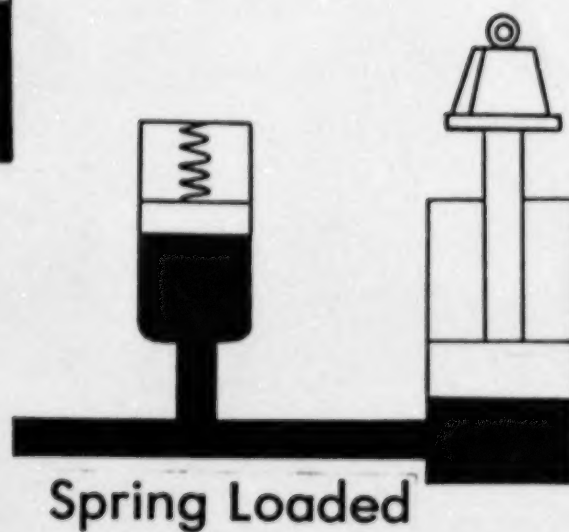
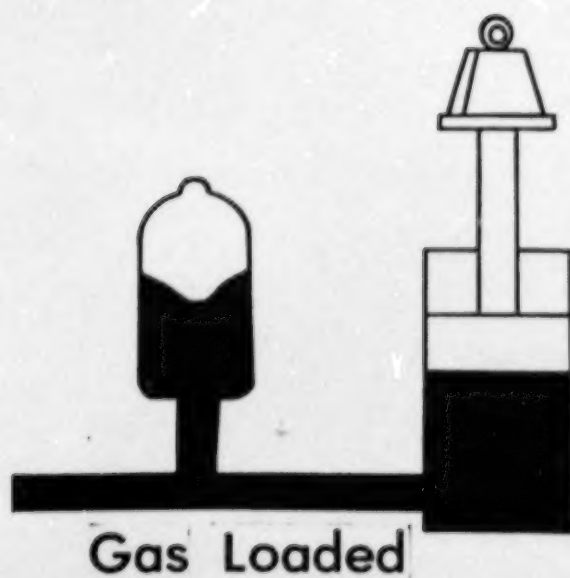
INFORMATION TOPIC: II-18

ANSWERS TO EVALUATION ITEMS:

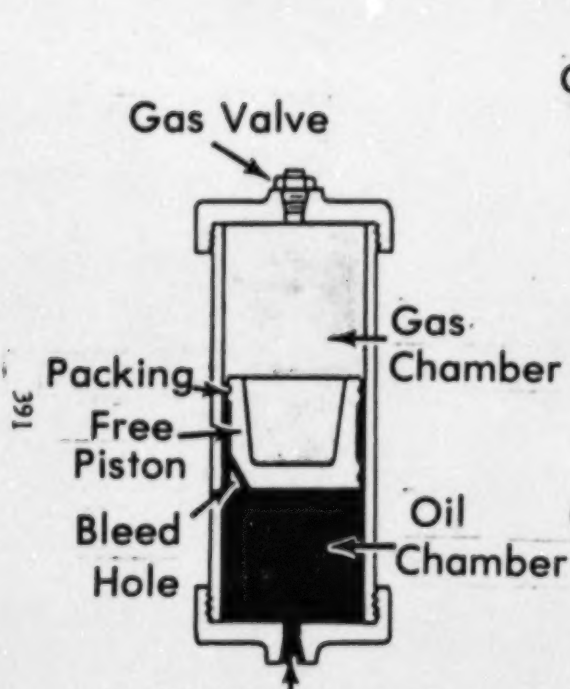
1.
 - a. **A device for storing hydraulic energy**
 - b. **A device for removing or adding heat to hydraulic fluids**
 - c. **A device for adding heat to hydraulic fluids**
 - d. **An automatic device for regulating temperature**
2. **b, c, d, f**
3.
 - a. **Gas-loaded accumulator**
 - b. **Weight-loaded accumulator**
 - c. **Spring-loaded accumulator**
4.
 - a. **Piston type**
 - b. **Bladder type**
 - c. **Diaphragm type**
5. **Any five of the following:**
 - a. **Always** discharge stored hydraulic fluid from the accumulator prior to removing it from the system.
 - b. **Never** charge an accumulator to a pressure more than that recommended by the manufacturer.
 - c. **Never** fill an accumulator with oxygen; an explosion could result if oil and oxygen mix.
 - d. **Only** fill the accumulator with an inert gas such as dry nitrogen, because dry nitrogen is free of water vapor and oxygen.
 - e. **Do not** use compressed air in an accumulator.
 - f. **Before** disassembling an accumulator release both gas and hydraulic pressures.
 - g. **Use** extreme care in removing the springs from spring-loaded accumulators.
6. **Explanation should include:**
 - a. **Power losses (inefficiencies) in various hydraulic components, such as pumps, valves, and lines, result in heating of the hydraulic fluid.**
 - b. **In order to prevent excessive operating temperatures, this heat must be removed.**
 - c. **The heat exchanger removes heat from the hydraulic system.**

7. Description should include:
 - a. Uses air moving past a radiator to dissipate the heat
 - b. Uses water flowing through tubes immersed in the oil to remove the heat
8. Any three of the following:
 - a. Cooling fins on air-to-oil heat exchangers become clogged with dirt and debris.
 - b. Water tubes on water-to-oil heat exchangers become plugged with sediment.
 - c. Water leaks into fluid.
 - d. Fluid leaks into water.
9. Explanation should include:
 - a. The viscosity of hydraulic fluid is sensitive to temperature; at cold temperatures the fluid is thick and severe pressure losses can occur in the lines.
 - b. In cold environments heaters are often used to help raise the temperature to the desired operating temperature or to help maintain the desired operating temperature.
10. Description should include:
 - a. Electric - uses electric heating element to add heat to the system
 - b. Heat exchanger - uses the same principle as when used to cool, except instead of removing heat, hot air or liquid is used to add heat
11.
 - a. Electrical heating element fails.
 - b. Heat exchanger fails.

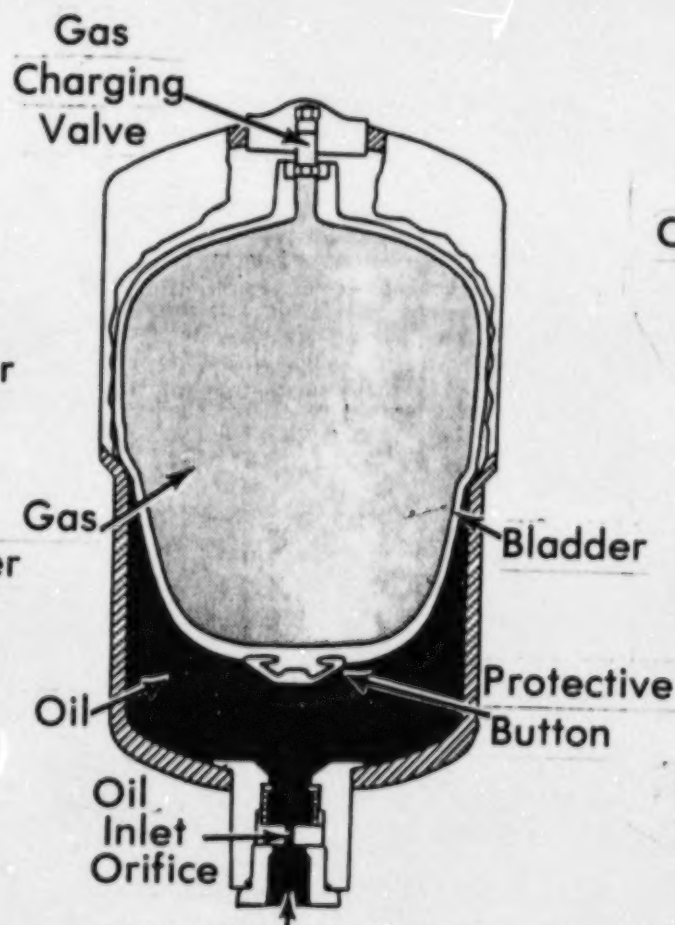
Types of Accumulators



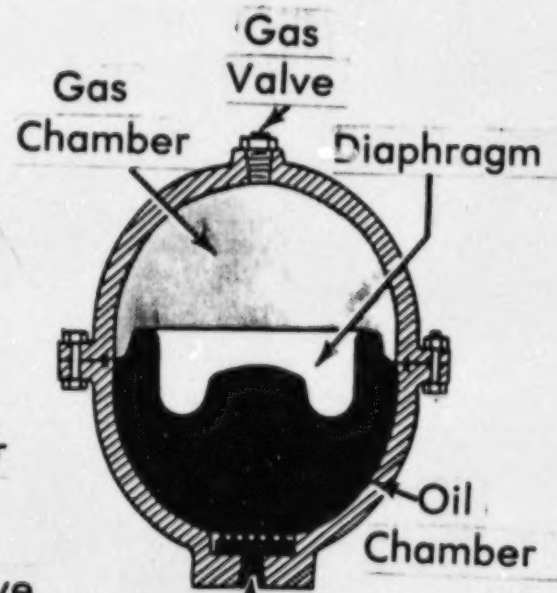
Types of Gas-Loaded Accumulators



To Hydraulic System
Piston Type Accumulator

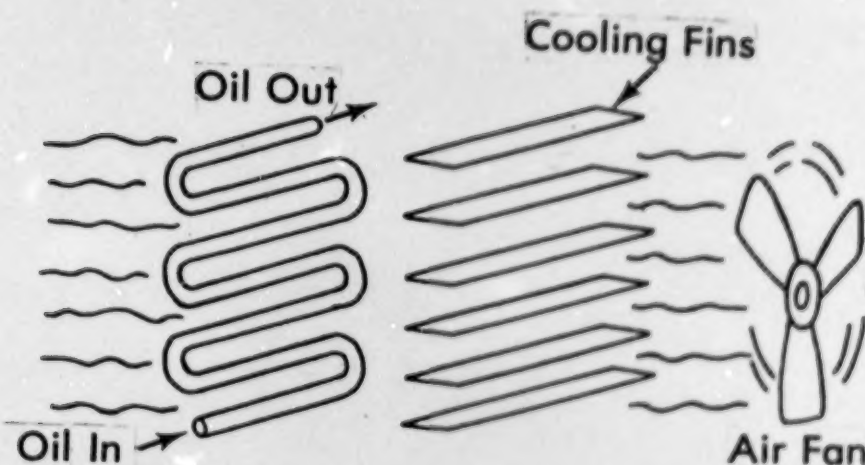


To Hydraulic System
Bladder-Type Accumulator in Operation

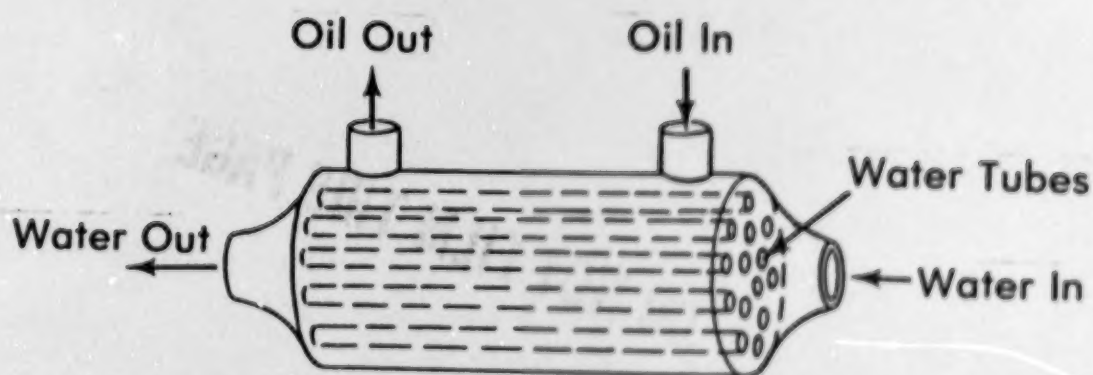


To Hydraulic System
Diaphragm-Type Accumulator

Types of Heat Exchangers



Air-to-Oil Heat Exchanger



Water-to-Oil Heat Exchanger